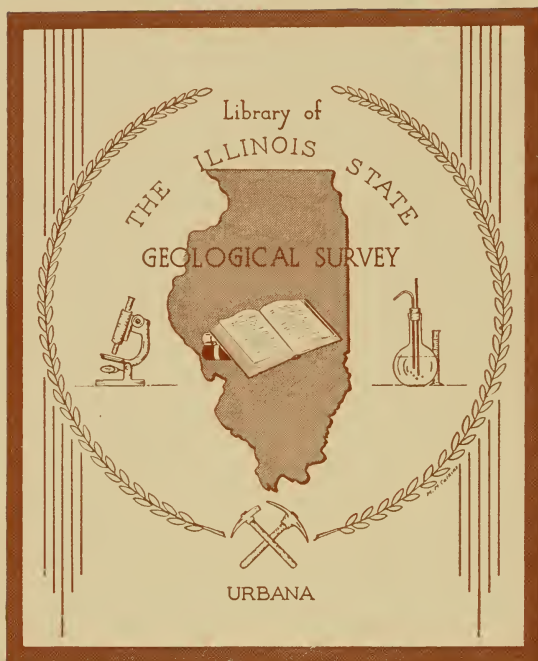


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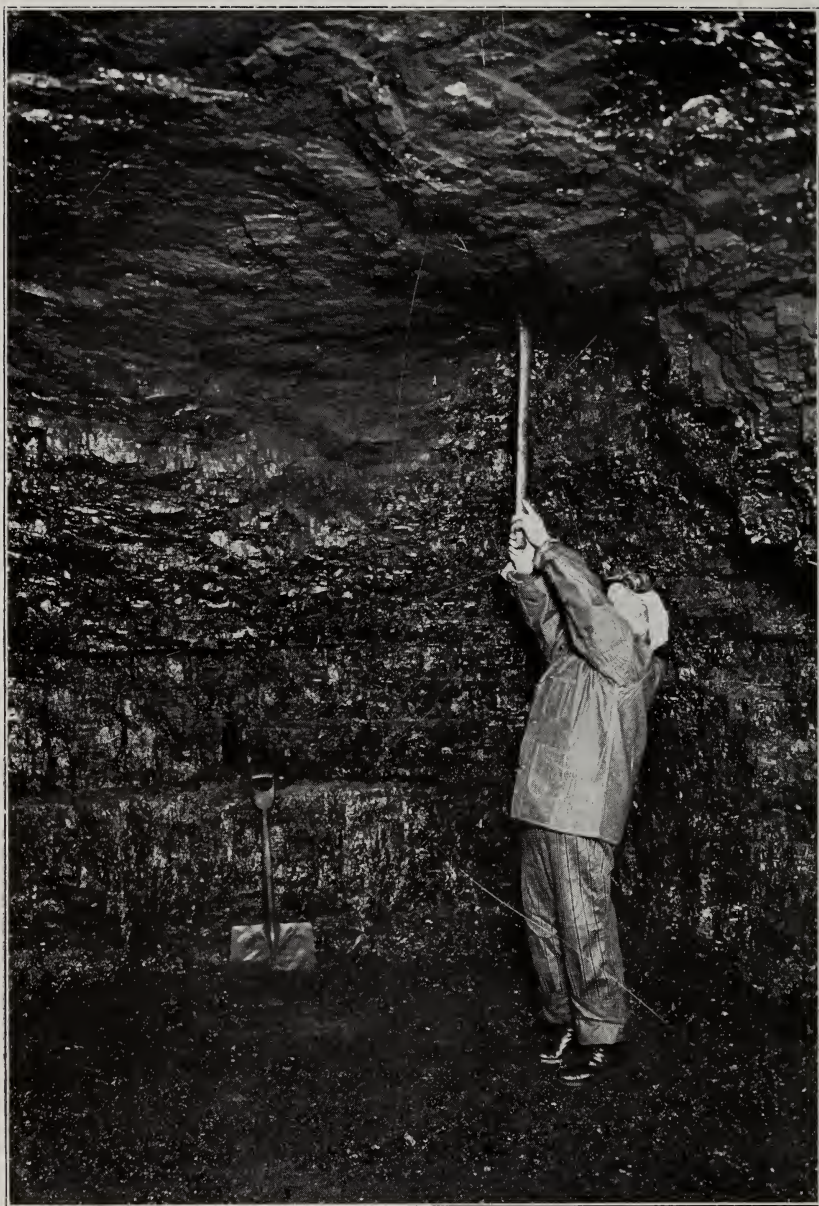




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Coal No. 6 near Christopher, Franklin County.

STATE OF ILLINOIS
DEPARTMENT OF REGISTRATION AND EDUCATION

DIVISION OF THE
STATE GEOLOGICAL SURVEY

M. M. LEIGHTON, *Chief*

BULLETIN NO. 56

ILLINOIS COAL

A Non-Technical Account of Its Occurrence
Production and Preparation

BY

A. BEMENT



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LETTER OF TRANSMITTAL

STATE GEOLOGICAL SURVEY DIVISION, December 2, 1931.


M. F. WALSH, CHAIRMAN, AND MEMBERS OF THE BOARD OF NATURAL
RESOURCES AND CONSERVATION,

GENTLEMEN :

The first edition of our educational bulletin on "*Illinois Coal: A Non-Technical Account of its Occurrence, Production, and Preparation*" has become exhausted. This bulletin was prepared primarily for the public rather than the technical reader, with the hope that it would answer authoritatively many questions which arise in the minds of the citizens of our State and others regarding the Illinois Coal Field, which is the source of our most important mineral industry. A second edition is now necessary to meet the demand for this popular bulletin and I therefore recommend its reprinting.

Very respectfully,

MORRIS M. LEIGHTON, *Chief.*



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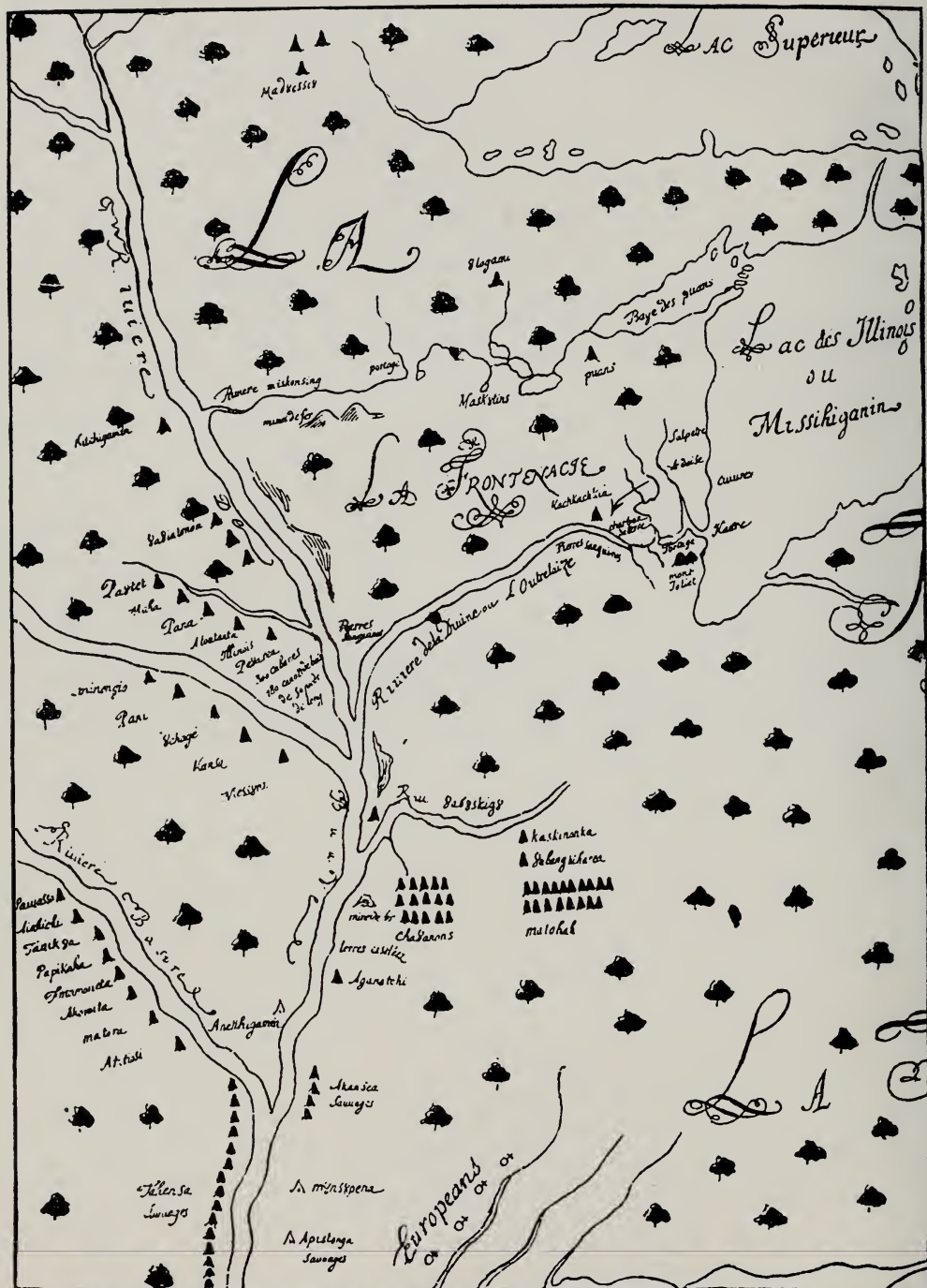
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THE CENTRAL PORTION OF JOLIET'S MAP, 1674, SHOWING THE MISSISSIPPI AS THE "BAUDE".
FIG. 1. Copy of Joliet's map made in 1674. (From "A History of the Mississippi Valley," by Spears and Clark.) The arrow has been added by the editor to show the position of the notation, "Charbon de terre".

ILLINOIS COAL

A Non-Technical Account of its Occurrence Production and Preparation

By A. Bement

CHAPTER I—GENERAL FEATURES OF THE ILLINOIS COAL FIELD

EARLY DISCOVERY

In many respects the Illinois Coal Field is a notable one. It was in Illinois that the first recorded discovery of coal was made on the North American continent. Joliet and Father Marquette in their voyage of exploration in 1673 by way of the Illinois valley and Chicago River made the original discovery some place between the present cities of Utica and Ottawa. Only the approximate site is marked by the words "Charbon de terre" (coal) on Joliet's map of 1674, the central portion of which is reproduced in figure 1. The same "Charbon de terre" appears on Marquette's map of 1681, and on Hennepin's map of 1689 a "cole mine" is shown on Illinois River above Fort Creve Coeur, now Peoria.

ORIGINAL COAL RESOURCES

When mining began in Illinois, the State contained more coal than any other state east of Missouri River, and indeed still contains much more unmined coal than even that possessed by any other state in the territory at the time mining operations were begun.

At the close of the Coal Measures period this was not true. At that time the eastern fields covered much more acreage and contained much more coal than the Central Interior field, of which the Illinois field forms the major part. The loss of this position by the eastern fields since that time was due to the Appalachian uplift, folding and elevating the rock strata to high exposed positions over large areas, where it has been subject to prolonged erosion and removal. What remained when mining began was but a fragment of the original. The Illinois field, however, was but slightly affected and still possesses most of the coal that was formed here during Coal Measures time, so that now this field has a commanding position with respect to available coal resources.

PRODUCTIVE COAL SEAMS

In the Illinois Coal Field there are but few seams of a sufficient thickness for profitable mining. Areas underlain by the principal seams are neverthe-

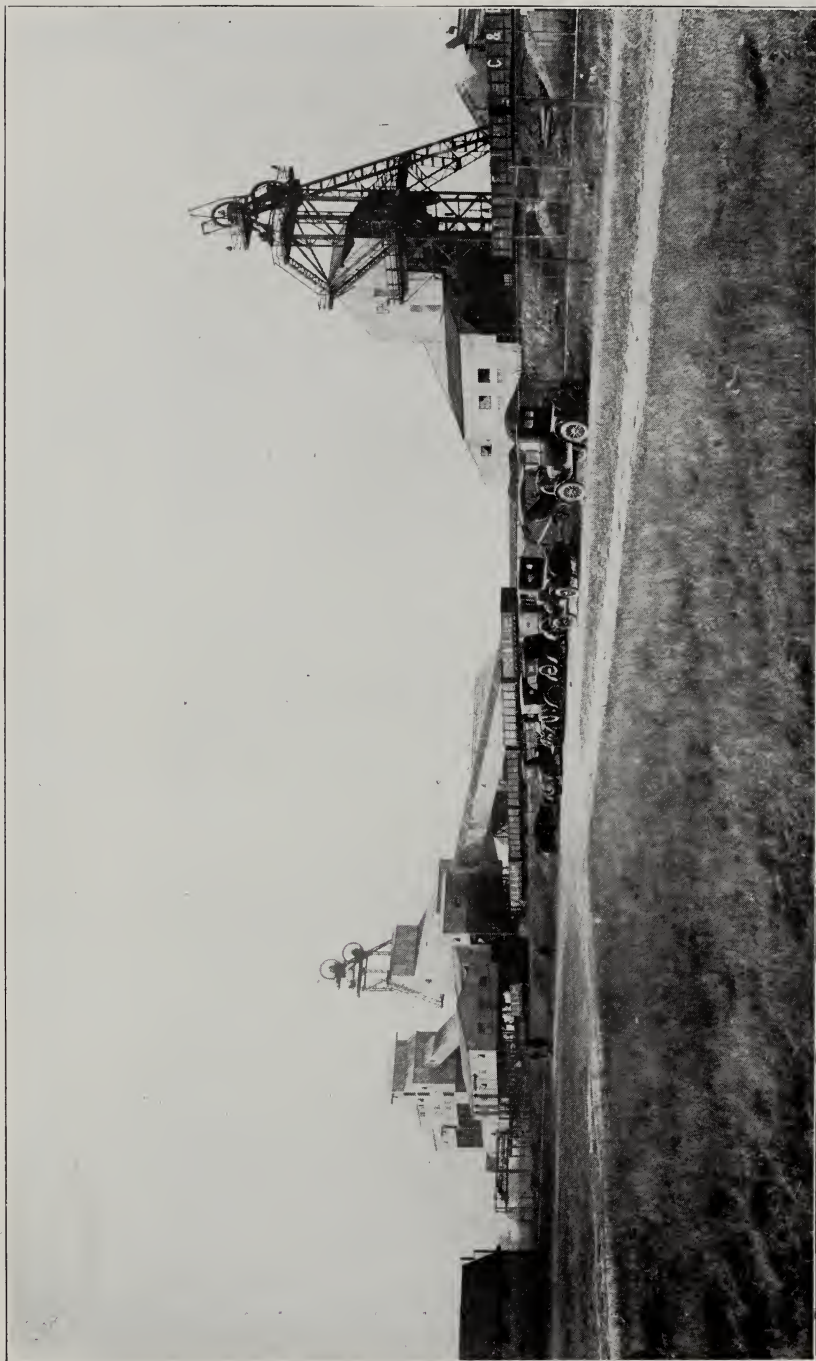


FIG. 2. Surface equipment of the largest coal mine in the world, Orient No. 2, at West Frankfort, Franklin County, Illinois. The shaft to the left is the main shaft, the one to the right is the air shaft.

less extensive and remarkably continuous, and conditions are favorable for economical mining. Thus far coal mined for shipment by rail has been confined to the product from seams Nos. 1, 2, 5, 6, and 7; comparatively little has been produced from seams Nos. 1 and 7. Formerly seam No. 2 was a commercially important source but at present production is largely confined to seams Nos. 5 and 6. By way of comparison, West Virginia ships coal by rail from as many as 22 recognized seams.

Different coal seams possess varying and individual characteristics, so when a user of coal finds that the product from a certain seam is suitable for his purpose it is natural that he should prefer shipment from that source. In Illinois, mining in any county is commonly confined to only one seam—excepting Sangamon County where No. 5 coal is mined north and No. 6 coal south of Auburn. A buyer who knows the shipping point can therefore be assured of the source of the coal. In this respect Illinois differs from West Virginia, Indiana, and Kentucky, for in those states more than one seam is commonly mined in a locality and the shipping point does not indicate the source of the coal.

The deepest bituminous coal mine in the United States is in Illinois. At Assumption, in Christian County, a shaft 1020 feet deep reaches what has generally been considered the No. 1 seam. Coal from this seam and from a seam just above, considered to be No. 2, was hoisted in this shaft for many years.

MODERN COAL MINES

The largest coal mines in the world are in Illinois. The largest mine is Orient No. 2 at West Frankfort in Franklin County. The surface equipment is shown in figure 2. This plant is electrically operated throughout with current purchased from the local public service company.

Formerly in Illinois coal mines a main or hoisting shaft served all purposes of operation so far as raising coal and lowering men and materials was concerned. As ventilation was essential, another opening was provided down which a fan forced air to circulate through the mine and find egress by way of the hoisting shaft. This air shaft also provided a means by which the men could leave the mine in case of an emergency and for that purpose it was equipped with stairs. It was realized, however, that other uses could be made of the air shaft, such as transporting men to and from the mine, handling materials required in the workings, and also serving as an adjunct to the main shaft for hoisting coal as occasion might require and when available for that purpose. These uses led to the equipment of the air shaft with head-frame cages, etc., much like the main shaft. Thus figure 2 seems to show two mines, or a twin mine, and illustrates the latest tendency in design.



FIG. 3. A rotary car-dumper, located at the shaft bottom, on to which cars of coal are run, clamped into position, and the coal discharged to a skip by turning the dumper over. The skip is a large steel tank which is hoisted to the tippie where it is so inverted that the coal runs off the skip. Only four mines are using this method; other mines hoist the mine cars to the tippie.



FIG. 4a. The main hoist at a large electrically operated mine, 4000 horsepower capacity, operated by a 2000 horsepower motor on each end of the shaft.

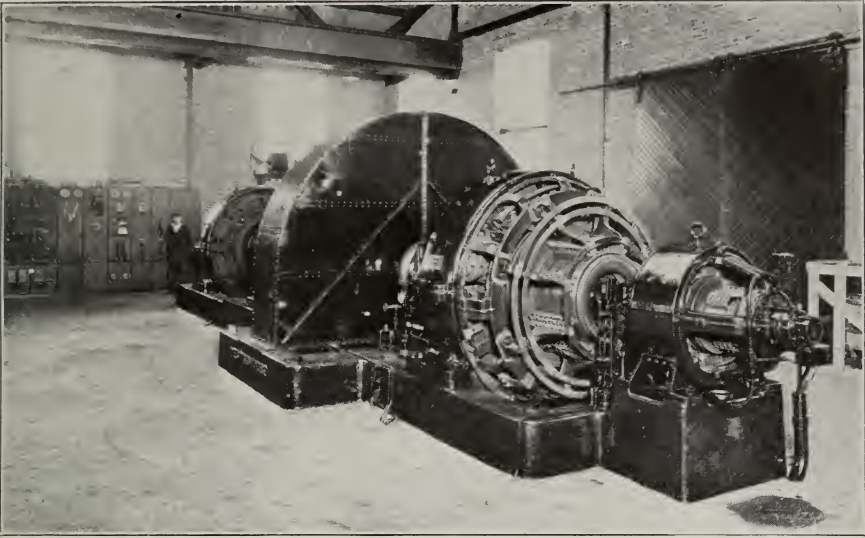


FIG. 4b. A motor generator set which operates in connection with the main hoist (Fig. 4a.) By means of the large and heavy fly wheel enclosed in a casing the voltage is kept up when the hoist starts, permitting the cage carrying the coal to attain high speed in the shortest time possible.



FIG. 5. The air shaft end of a modern mine in Saline County, similar to that shown in figure 2.



FIG. 6a. Shaft bottom of the mine shown in figure 5. From the elevator platforms, which here lie at a depth of 500 feet below the surface, mine cars loaded with coal are automatically caged, hoisted and emptied in thirty seconds, and the round trip made in one minute. The walls and arch are of concrete construction.



FIG. 6b. The double arch shown in figure 6a and the empty-car side (left) of the men and materials shaft.

As the coal arrives in the mine cars at the bottom of the hoisting shaft, it is loaded by a rotary dumper (fig. 3) into skips, which are large steel buckets, hoisted to the tippie and discharged into weigh hoppers. After it is weighed it passes through the tippie. The electrical hoist (fig. 4a), which is run at high speed, is reinforced by a motor generator set (fig. 4b). This electrical equipment is similar to that employed at several other mines in both the southern and central Illinois districts.

Figure 5 shows the air shaft end of another partially completed modern plant in Saline County. Hoisting is by steam, and other power requirements are supplied by purchased electric current. The mine cars are automatically fed onto the hoisting cage (figs. 6a and 6b), raised to the tippie, and their contents discharged to the weigh hoppers.

COAL SIZING¹

Illinois leads all other coal-producing states of the country in preparation, or sizing, of coal. Experience has shown that the requirements of coal for a specific use are best met when the coal is appropriately sized, for this supplements and greatly increases its effective heating power. Both demand and natural advantages have combined to stimulate the development of coal preparation, and the better operators now assume the position of preparateurs rather than producers of raw material.

Coal sizing in Illinois has been made possible in a large measure by naturally favorable ground-surface conditions. In the East, where mining is principally along creeks in narrow valleys, little or no flat ground is available for tippie locations. Where there is room for only one track, loading is limited to one size which must be mine run. Where there is room for two tracks, screenings and one other grade—a mixture of all other sizes known as lump coal—may be loaded. Where mining consists largely in working out hilltops of limited area the expense of removing enough of the hillside to accommodate the additional tippie equipment and loading tracks is prohibitive. On the flat prairies of Illinois, however, there are no such limitations, and coal producers have been able to erect plants adequate for the preparation of coal and to build extensive rail yards to care for car storage and movement (fig 7).

The railroad trackage at a large mine is equal to the side trackage that would serve a small city. At an Illinois mine which makes a partial preparation, the standard tippie, in addition to storage tracks, requires five tracks for the accommodation of the railway cars when loaded—one track for each of the following sizes: lump, over 6 inches; furnace, 6 by 3 inches; small egg, 3 by 2 inches; No. 2 nut or stove, 2 by 1½ inches; 2-inch and 1¼-inch screen-

¹ See Chapter VI on Prepared Coal.



FIG. 7. View of the first mine sunk in Franklin County showing the main tippel, re-screening plant, power plant, extensive rail yard, and the flat prairie. The piles of mine timber and railroad ties in the foreground are used for roof support and mine railroad tracks.

ings. No. 2 nut is loaded on the same track as the 2-inch screenings, for when No. 2 nut is made no 2-inch screenings are produced. In this way six regular sizes of coal are loaded on five tracks.

In Illinois mines making a full preparation (see Chapter VI), standard practice requires a re-screening plant to which 1¼-inch screenings are conveyed for separation and loading independent of the main tippie. Harco mine No. 7 at Harco, Saline County, is a unique example of a mine having a re-screening plant combined in a seven-track tippie which makes and loads nine standard sizes, three extra sizes in addition to those noted above. The extra sizes are: chestnut or No. 3 nut, 1½ by ¾ inches; pea, ¾ by ⅜ inches; and carbon, less than ⅜ inch. The No. 3 nut and the 1¼-inch screenings are loaded on one track, and 2-inch screenings and No. 2 nut also on one track.

COAL SHIPMENTS WITHIN THE STATE

For nearly thirty years there has been a growing movement of coal from southern districts into other coal-producing districts within the State. For example, Decatur, with two mines in town which allow of direct delivery from shaft to consumer, imports southern coal. Likewise LaSalle and Peru, with a mine shaft on the main street of each town, purchase part of their domestic supply from the southern district, 250 miles away, and the electric power plant at LaSalle uses stoker fuel from the same source. The shift of production from north to south has been remarkable in view of the fact that northern fields are commonly nearest to market. Table 8 (p. 44) shows LaSalle County as the leader in production in 1881; the peak of production, moving south, reached Williamson County in southern Illinois in 1907, where it remained until Franklin County assumed the leadership in 1915.

PROPORTION OF COAL RECOVERY

In Illinois mines about one-half the coal is unrecovered, the amount of recovery being much less than in the eastern fields. Low percentage of recovery is partly due to the necessity of leaving pillars in compliance with the demands of property owners. Extraction in the longwall field where no pillars are left represents about 95 per cent of the coal, but extraction by the room-and-pillar method is probably about 50 per cent.

MINING DISTRICTS

Figure 8 shows areas known to be underlain by the principal coal seams, and figure 9 outlines the ten general trade districts. The Big Muddy district has been worked out and is shown for historical reasons only. There has been no commercial underground mining for several years in the original Wilmington field, but this district is again producing because of the recent opening of a large stripping operation within its boundaries.

Early mining was confined largely to the northern and southwestern portions of the coal field. LaSalle and Grundy counties in northern Illinois and Madison and St. Clair counties in southern Illinois were particularly

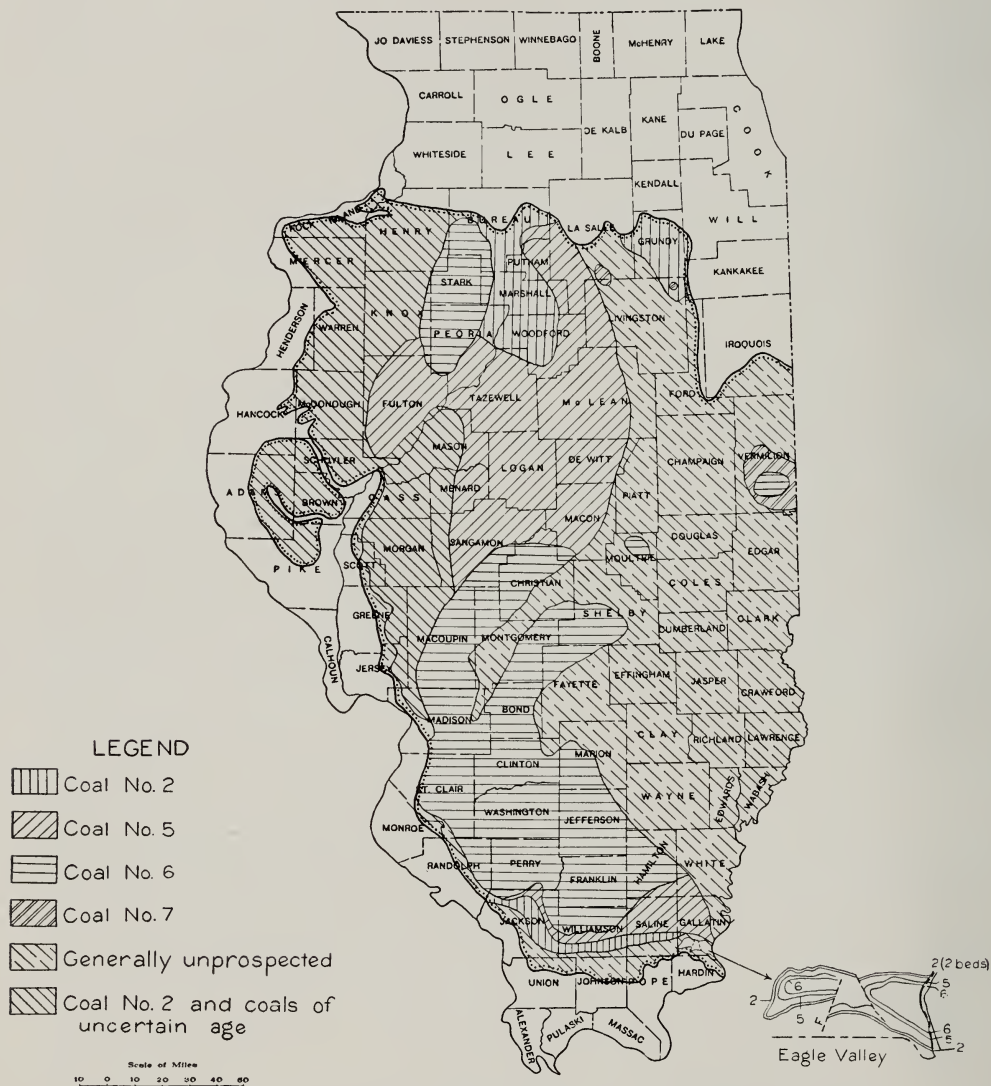


FIG. 8. Map of Illinois showing general distribution of principal coal seams¹

important in the production of coal. Madison and St. Clair counties originally furnished St. Louis with most of its coal supply. The only other important mining area was the Big Muddy District in Jackson County near the southern

¹ Field investigations by Dr. H. B. Wilman in the summer of 1930 have shown that the coal in LaSalle, Bureau, and Putnam Counties mapped as No. 5 is probably coal No. 6.

extremity of the State. The No. 2 coal mined there furnished the best quality coal then produced in the State. Figures 10 and 11, which show the

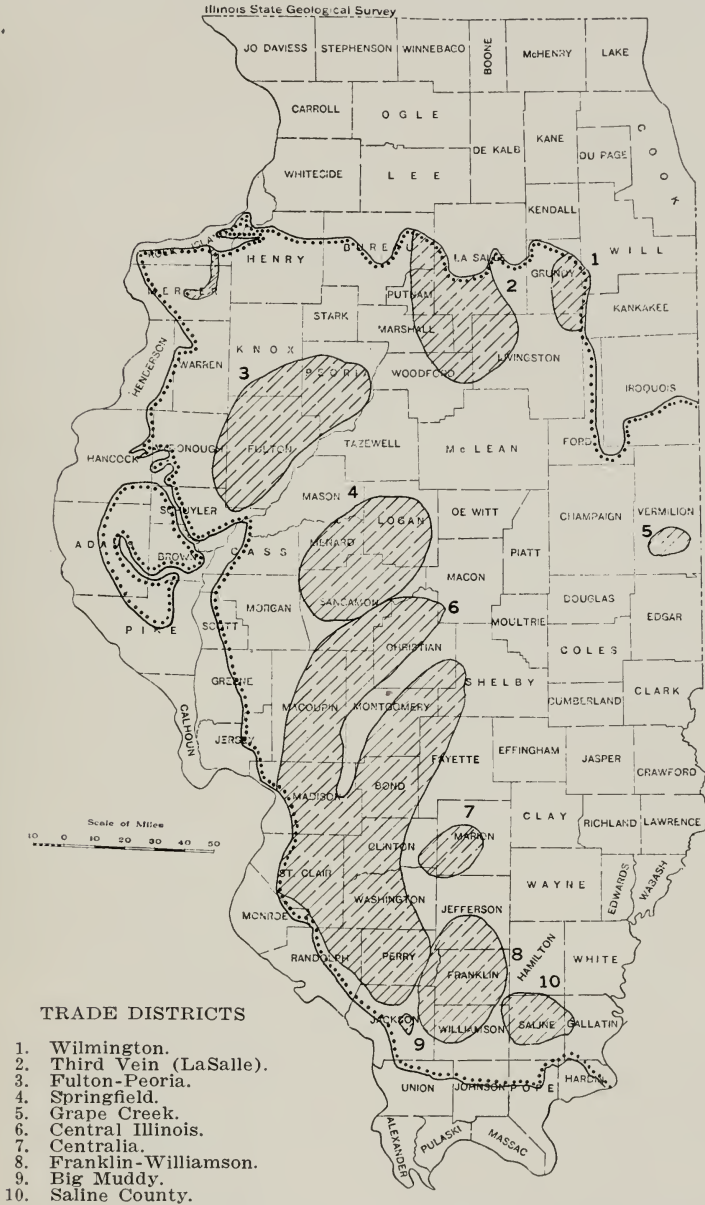


FIG. 9. Map of Illinois showing the location of the ten principal trade districts.

centers of production in 1880 and 1925 respectively, bring out strikingly the southward shift in production.

VARIATIONS IN PRODUCTION

Figure 12 shows the average curve of annual production for the State as a whole from 1882 to 1925. The broken line indicates that if normal demand

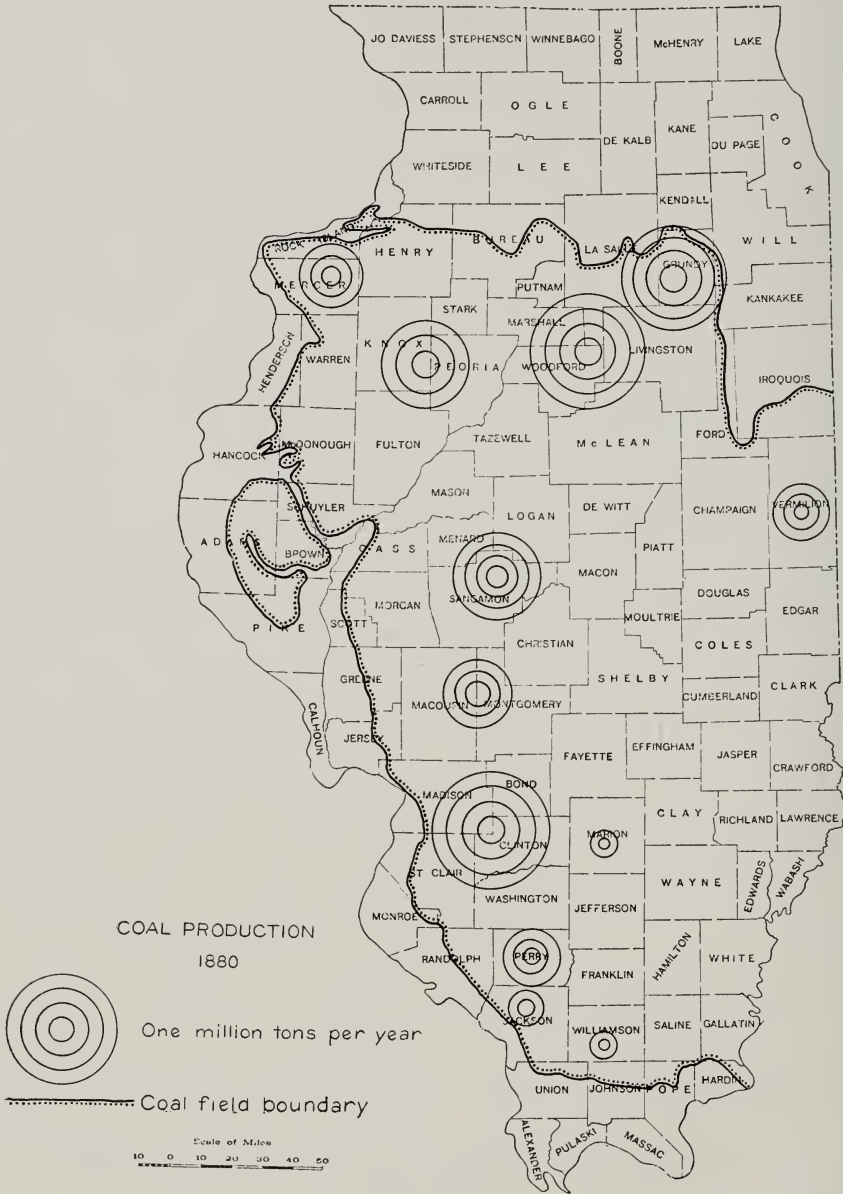


FIG. 10. Map of Illinois showing the location of mining and also the relative production from different localities in 1880.

had continued to 1925, production would have reached 93,000,000 tons. In determining the normal curve the abnormal years of 1917, 1918, 1921, and

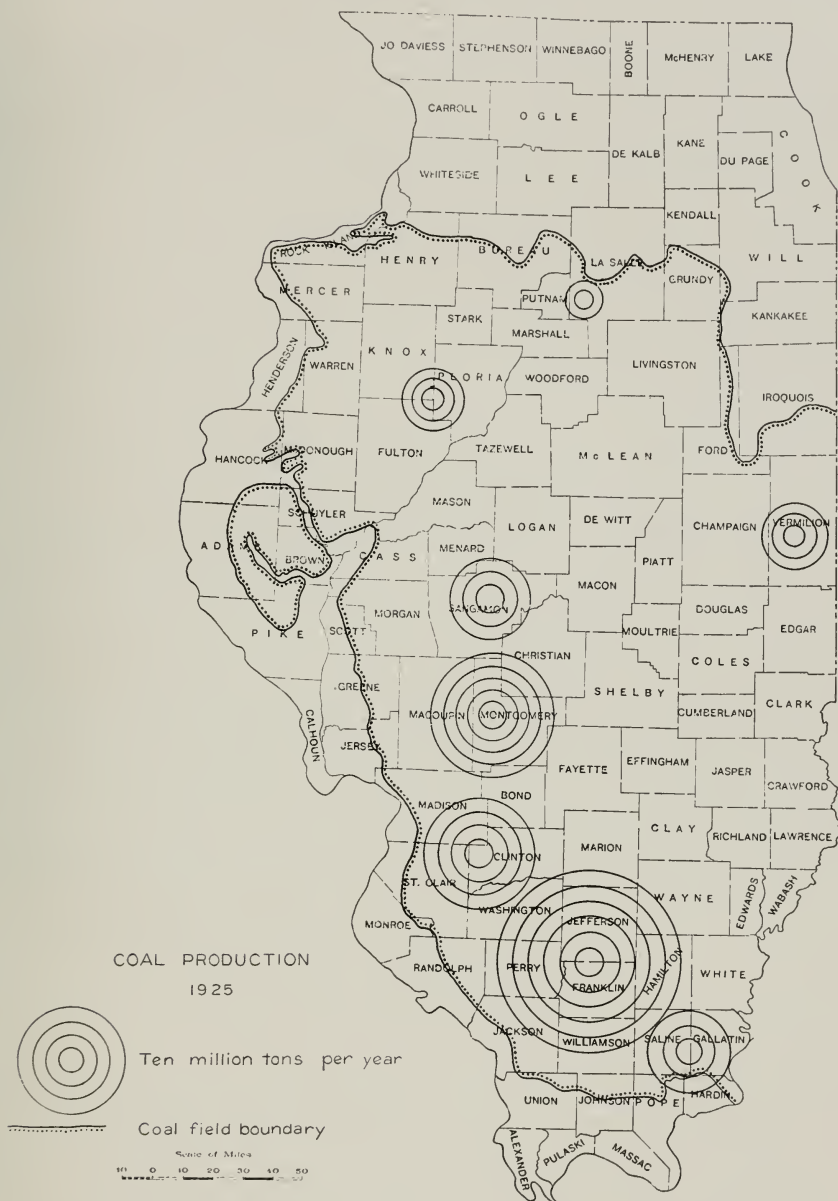


FIG. 11. Map of Illinois showing the location of mining and also the relative production from different localities in 1925. In comparing figures 10 and 11 the difference in production scale should be noted.

1922 were not considered. The demand in 1917-1918 was due to the World War, 1921 was a year of exceptional industrial activity, and in 1922 there was a five month's interruption due to miners' strike.

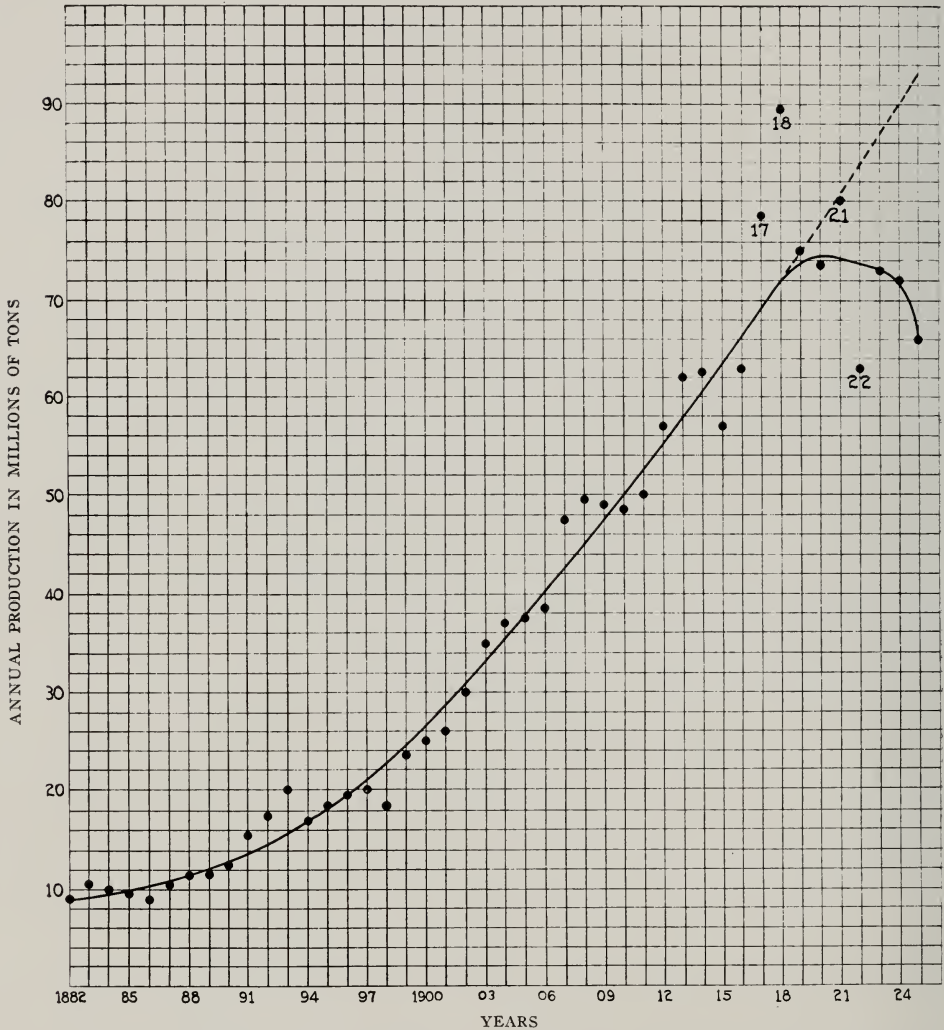


FIG. 12. Average curve of Illinois coal production in millions of tons from 1882 to 1925. The dotted line shows what would have been attained if the normal trend had continued. Dots 17, 18, 21 and 22 were ignored in plotting the upper part of the curve for they represent productions of abnormal years, 1917 and 1918 being the years of the World War, 1921 a year of abnormal demand, and 1922 a year of five months' suspension due to labor trouble.

Figure 13 shows the average curves of production for three parts of the State, northern, central, and southern, in which Sangamon County is consid-

ered typical of the central portion. Figure 14 shows the average percentage curves, based on State totals, for the same three divisions. These two graphs picture rather strikingly the change in leadership in production from north to south. The northern districts, where the longwall method of mining is em-

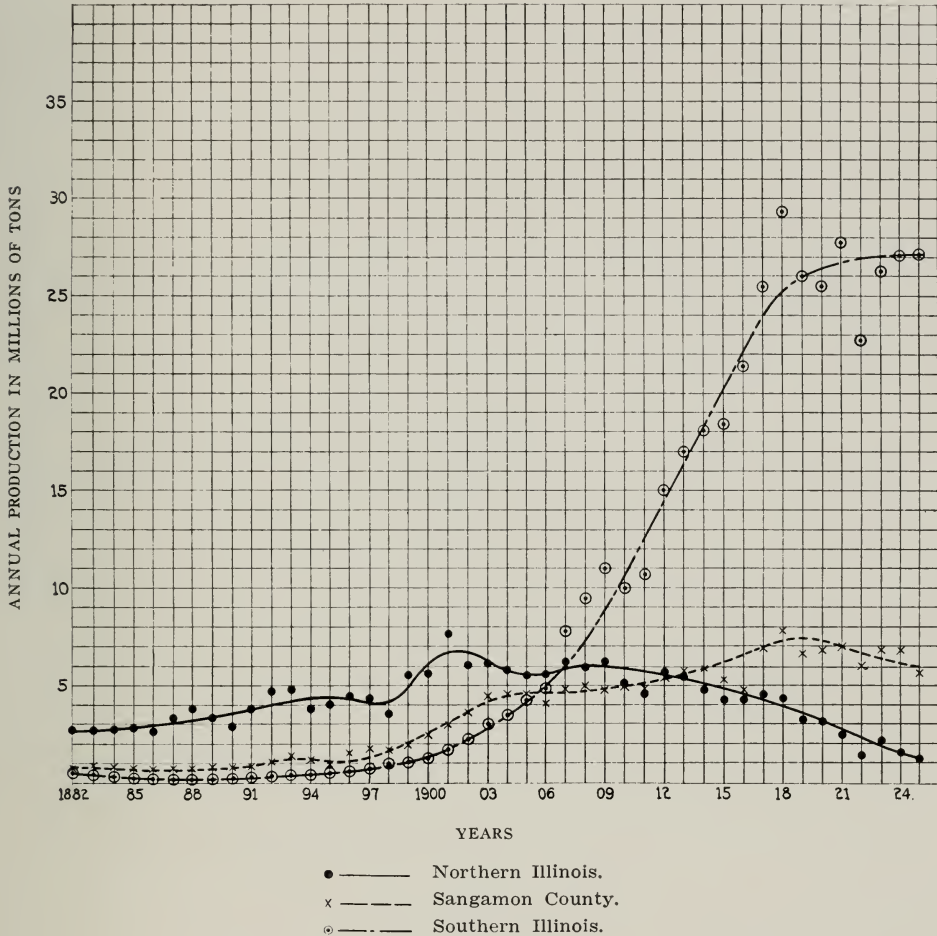


FIG. 13. Average curves of production for Northern Illinois (Third Vein and Wilmington districts), Sangamon County, and Southern Illinois.

ployed, although nearer the large markets, have not been able to compete with the lower cost of production and the better coal from the southern districts

It appears from figure 14 that the increase of production in southern Illinois has been greater since 1922 than previous to that time, but by refer-

ence to figure 13 it may be seen that the actual increase was very slight, that the district has no more than maintained its rate of production and that the

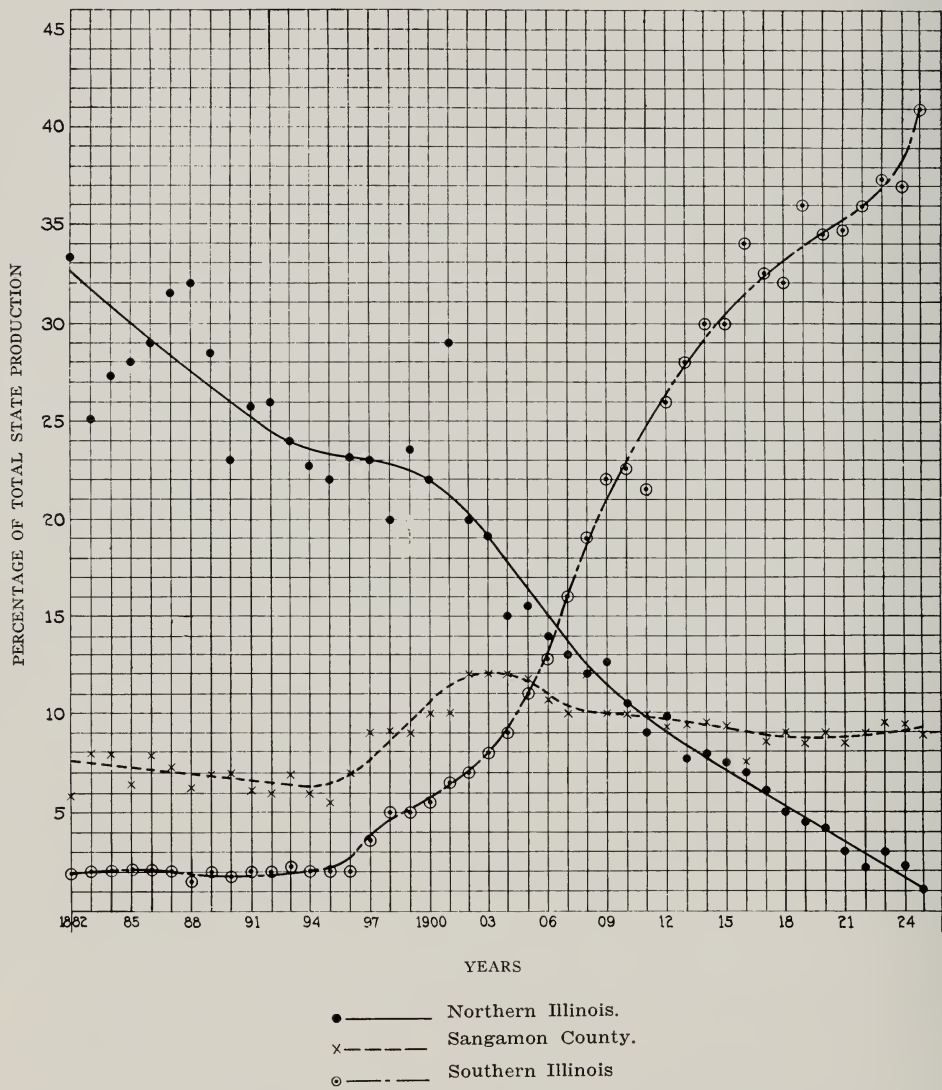


FIG. 14. Average percentage curves based on State totals, for Northern Illinois, Sangamon County, and Southern Illinois. (See fig. 9.)

apparent rapid increase here is due to actual decline elsewhere. In other words, the production of southern Illinois has remained about constant while that of other portions of the State has decreased.

CHAPTER II—GEOLOGY OF THE ILLINOIS COAL FIELD¹

The extent of the Illinois coal field, the areas in which the important coal beds occur in conditions suitable for mining, and the principal trade districts, are shown in a generalized way in figures 8 and 9. More detailed maps and descriptions are given in other publications of the Illinois Geological Survey.²

DIVISIONS OF THE PENNSYLVANIAN SYSTEM

The series of coal-bearing rocks known as the Pennsylvanian system, commonly called the Coal Measures, has been subdivided in Illinois into three

¹ This general description of the geology of the coal field has been prepared in collaboration with Dr. G. H. Cady, Geologist in charge of Coal Studies, Illinois State Geological Survey.

² Mining Investigations bulletins: Bulletin 1. Preliminary Report on Organization and Method of Investigations. Out of print.

Bulletin 3. Chemical Study of Illinois Coals, by S. W. Parr, 1916. Out of print.

Bulletin 10. Coal Resources of District I (Longwall), by G. H. Cady, 1915. Out of print.

Bulletin 11. Coal Resources of District VII, by Fred H. Kay, 1915. Report includes Bond, Clinton, Christian, Fayette, Macoupin, Madison, Marion, Montgomery, Perry, St. Clair, Shelby, Washington and parts of Randolph and Sangamon counties.

Bulletin 14. Coal Resources of District VIII (Danville), by Fred H. Kay and K. D. White, 1915.

Bulletin 15. Coal Resources of District VI, by G. H. Cady, 1916. Report includes Williamson, Franklin, and Jefferson counties.

Bulletin 16. Coal Resources of District II, by G. H. Cady, 1917. (Jackson County.) Out of print.

Bulletin 17. Surface Subsidence in Illinois Resulting from Coal Mining, by Lewis E. Young, 1916.

Bulletin 18. Tests on Clay Materials Available in Illinois Coal Mines, by R. T. Stull and R. K. Hursh, 1917.

Bulletin 19. Coal Resources of District V, by G. H. Cady, 1919. (Saline and Gallatin counties.)

Bulletin 20. Carbonization of Illinois Coals in Inclined Gas Retorts, by F. K. Ovitz, 1918.

Bulletin 21. The Manufacture of Retort Coal-Gas in the Central States Using Low-Sulphur Coal from Illinois, Indiana and Western Kentucky, by W. A. Dunkley and W. W. Odell, 1918.

Bulletin 22. Water-gas Manufacture with Central District Bituminous Coals as Generator Fuel, by W. W. Odell and W. A. Dunkley, 1918. Out of print.

Bulletin 23. Mines Producing Low-Sulphur Coal in the Central District, by Gilbert H. Cady, 1919.

Bulletin 24. Water-gas Operating Methods with Central District Bituminous Coals as Generator Fuel, a Summary of Experiments on a Commercial Scale, by W. A. Dunkley and W. W. Odell, 1919.

Bulletin 25. Gas Purification in the Medium-size Gas Plants of Illinois, by W. A. Dunkley and C. E. Barnes, 1920.

Bulletin 26. Coal Resources of District IV (Peoria-Springfield), by G. H. Cady, 1921.

Bulletin 27A. Analyses of Illinois Coals, compiled by G. W. Hawley, 1923.

Bulletin 28. Preliminary Report on Coal Stripping Possibilities in Illinois, by Harold E. Culver, 1925.

Bulletin 29. Coal Resources of District III (Western Illinois), by Harold E. Culver, 1925.

Bulletin 30. Coal Losses in Illinois, by C. A. Allen, 1925.

Bulletin 31. Coal Stripping Possibilities in Southern and Southwestern Illinois, by G. H. Cady, 1927.

formations. These divisions are believed to correspond in the main to subdivisions of the same system in the Appalachian region. In both regions the lowest formation is called the Pottsville. The formation above the Pottsville in Illinois is designated as the Carbondale, which in a general way corresponds to the Allegheny formation of Pennsylvania. The upper formation in Illinois, the McLeansboro, begins at about the same position as the Conemaugh formation of the East. Still higher formations are present in Pennsylvania, but it is unknown whether or not part of the Illinois McLeansboro corresponds in



FIG. 15. An outcrop of No. 6 coal (indicated by the two lines) and associated strata near Brereton, Fulton County. Note the limestone cap rock. No. 6 coal is here $4\frac{1}{2}$ feet thick, whereas in southern Illinois its thickness ranges from 6 to 14 feet.

age to any of these higher formations of the eastern field. This three-fold subdivision must be considered as tentative, pending more detailed study.

The Pottsville formation includes No. 1 coal and all beds below No. 2 coal; the Carbondale formation begins at the base of No. 2 coal and extends through No. 5 coal to the top of No. 6 coal; the McLeansboro formation includes all beds above No. 6 coal. The No. 7 coal is the only important coal bed in this formation, and it lies near the base.

POTTSVILLE FORMATION

The Pottsville formation outcrops in a narrow fringe only a few miles wide around the border of the basin, except for a short space where it is missing along the Mississippi bluff line in St. Clair and Madison counties. In this place the formation is absent beneath beds of Carbondale age. Its

thickness varies greatly: in northern Illinois it is commonly thin, from a few inches to 100 feet or so thick; in southern Illinois, particularly east of the structure known as the Duquoin anticline, it reaches a thickness of 800 to 1000 feet in Saline, Franklin, and Williamson counties.

CARBONDALE FORMATION

The Carbondale formation outcrops in a narrow belt paralleling and lying within the outcrop belt of the Pottsville formation in southern Illinois, but underlies considerable wider areas in northern and western Illinois. The formation ranges in thickness from about 120 feet in Fulton County to about 400 feet in Saline and Gallatin counties. This represents the interval between coals Nos. 2 and 6 in these regions. In parts of the coal basin, particularly in St. Clair³ and Randolph counties and the west part of Washington County, the Carbondale formation is thin because the lower part is absent, and as the Pottsville formation is also absent, beds representing the upper part of the Carbondale rest directly on strata older than the Pottsville. The surface rocks in the area in figure 8 described as coal No. 2 and coals of uncertain ages are probably largely of Carbondale age with narrow fringes of Pottsville. Figure 15 is a photograph of an outcrop of No. 6 coal and associated strata near Brereton, Fulton County.

MCLEANSBORO FORMATION

The McLeansboro formation, which is the uppermost formation over most of the Illinois coal basin, in most places overlies both the Pottsville and Carbondale formations. The McLeansboro formation is relatively thick so that certain shafts, as at Lovington, have penetrated about 900 feet of strata before reaching coal thus far designated as the No. 6 seam. Most coal shafts in the State that extend to No. 6 coal have a depth of more than 200 feet, and outside of St. Clair, Williamson, and possibly Perry counties, the depth is commonly greater than 300 feet. In Jefferson and Christian counties there are four shafts more than 700 feet deep, which below the surface covering of glacial drift or alluvium are entirely in the McLeansboro formation. Its greatest thickness is in Wayne County.

NOMENCLATURE OF ILLINOIS COAL SEAMS

Reference to Illinois coal seams is commonly made by number, but as the accuracy of widespread correlation of the coals has not yet been demonstrated, it is customary for the State Survey to refer to the coals by local geographic name as well as by number. Thus the local or regional identity of the coal is assured, which might not be the case if a number were used.

³ Field evidence available since 1929 indicates that No. 2 coal of northern Illinois is probably younger and hence lies above the Murphysboro (No. 2) coal of southern Illinois. The LaSalle (No. 2) coal is probably present in western St. Clair County but the Murphysboro (No. 2) coal is not.

This is important because the thickness, quality, and mining conditions of a given coal bed may differ in different parts of the State. Such a method was employed by the Second Geological Survey of Pennsylvania. In that state coal beds were identified by local names, such as towns, then when an intermediate bed was located it was given a name that could be inserted in the list at its proper place. If a numerical system had been adopted it would have been necessary to insert numbers either with fractions or with prefixes or suffixes. Table No. 1 presents the numerical order together with the local designations now used in Illinois.

TABLE 1—*Nomenclature of principal Illinois coal seams*

<i>Numerical designation^a</i>	<i>Geographic designation</i>
Coal Seam No. 1	Rock Island (No. 1) coal
	Seville (No. 1) coal
	Assumption (No. 1) coal
Coal Seam No. 2	LaSalle (No. 2) coal
	Colchester (No. 2) coal
	Murphysboro (No. 2) coal
Coal Seam No. 5	Springfield (No. 5) coal
	Rushville (No. 5) coal ^b
	Harrisburg (No. 5) coal
	Blair (No. 5) coal ^b
Coal Seam No. 6	Belleville (No. 6) coal
	Herrin (No. 6) coal
	Grape Creek (No. 6) coal
Coal Seam No. 7	Streator (No. 7) coal
	Danville (No. 7) coal

^a Field investigations by Dr. H. E. Wanless in 1929 and 1930 have determined the identity of certain lenticular coals, for example, that mined at Soperville in Knox County, as coal No. 4. A coal bed which is probably at the same stratigraphic position and which apparently is of workable thickness at only a few places, is mined at Greenfield in Greene County and near Neeleys in western Morgan County.

^b Rushville and Blair coals are equivalent respectively to the Springfield and Harrisburg coals, but the names are used locally and are therefore included here.

In addition to the five numbers used to designate the more important coal seams eleven others have been used, so that sixteen seams have been identified here and there in the State. These numbers were applied many years ago by the original Geological Survey of 1858-1885, and many of them refer to beds that are thin and only locally developed. It has since been found that these numbers cannot be applied widely, except with respect to the five thick seams, and it seems possible that even here the application has been too extended.

STRUCTURE OF ILLINOIS COAL FIELD

An important characteristic of the Illinois coal mines is the general absence of structural irregularities. Faults and other disturbances are not nume-

rous and except for certain mines in Williamson, Franklin, and Saline counties they have little effect upon mining operations. In most of the mining districts the irregularities that affect the cost and limit the possibility of mining consist of variations in the thickness of the bed and in the character of the roof material. In some places the coal beds may locally contain lenses of clay, sand, or "bone" that add to the cost of mining. In places in Peoria, Montgomery, and Saline counties, in certain mines coal beds have been found terminating against masses of sandstone which represent the filling of channels that existed during the coal-making period.

LASALLE ANTICLINE

That mining operations are in general free from difficulties due to structural irregularities is because of the general avoidance of at least two of the three regions where such irregularities are found.

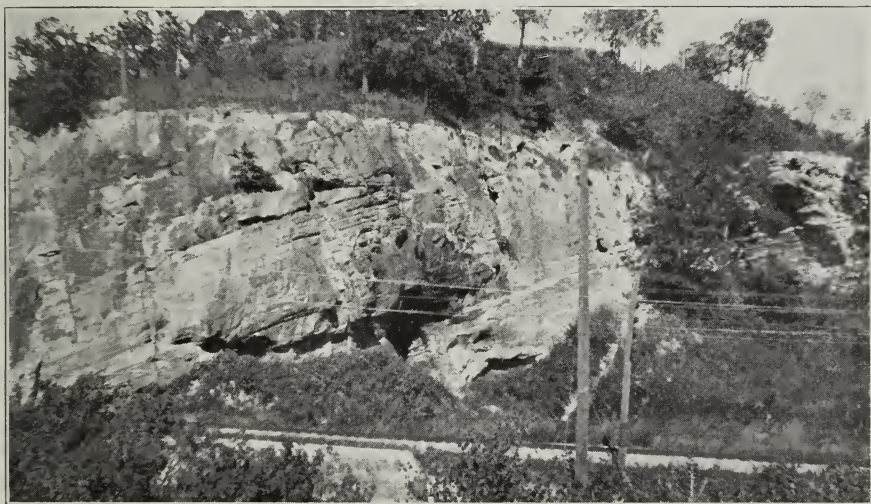


FIG. 16. Dipping strata on the west flank of the LaSalle anticline, at Split Rock, two miles east of LaSalle.

The most important of these structures is the LaSalle anticline, which enters the coal basin from the northwest, east of the city of LaSalle. Figure 16 shows the westward dip of strata on the west flank of the LaSalle anticline at Split Rock, east of LaSalle. This fold extends southeasterly, in varying prominence, through Livingston, Ford, Champaign, Douglas, Coles, Clark, Crawford, and Lawrence counties. Along this line are located the producing oil fields in Cumberland, Clark, Crawford, Lawrence, and Wabash counties. In Champaign, Douglas, and Edgar counties, the Pennsylvanian strata have been entirely removed from the crest of the fold so that coal-bearing strata

in Vermilion and Edgar counties are entirely isolated from strata of similar age in the central part of the Illinois basin. This structure accounts for the lack of close association between the main Illinois field and the main Indiana field. Within recent years only one coal mining operation in the State has been located on the LaSalle anticline.

DUQUOIN ANTICLINE

A second important structural irregularity is the Duquoin anticline. Both the LaSalle and Duquoin structures are asymmetrical folds; one slope is steep and the other gentle or nearly flat. The Duquoin anticline, which has its steep limb on the east, extends along the line of the Third Principal Meridian and is particularly prominent between Sandoval, Marion County, and Elkhville, Jackson County. By reason of the fold, the Herrin (No. 6) coal lies about 400 feet above sea-level at Duquoin and about at sea-level two miles east. The folding has been accompanied by considerable faulting, especially near Dowell and Hallidayboro south of Duquoin and at Centralia. Studies have definitely established that what prior to 1908 was called No. 7 coal, lying east of Duquoin, is the same as the Herrin (No. 6) coal mined west of Duquoin.

The anticline is important, not only as a zone of displacement, but as marking the approximate boundary between coals of definitely diverse character, and hence it roughly separates two trade districts—No. 8 and No. 6 (fig. 9). Figure 44, page 96, shows that the coal east of the Duquoin anticline has a heating value definitely higher than that of the coal west of that structure. Moisture and ash content also vary similarly. One mining operation south of Duquoin and three at Centralia are located on the Duquoin anticline.

FAULTED BELT ACROSS SOUTHERN ILLINOIS

A third line of disturbance crosses southern Franklin, Williamson, Saline, and Gallatin counties in a narrow zone extending through the vicinity of Royalton in Franklin County to near Equality in Gallatin County. The zone probably crosses the Duquoin anticline between Dowell and Hallidayboro in Jackson County and continues westward as the Campbell Hill anticline. It can be traced eastward in the mines across southwestern Franklin County and Williamson County and on the surface and in the mines across eastern Williamson, Saline, and western Gallatin counties.

The irregularities in this belt consist of a series of discontinuous faults, those of major importance trending slightly south of east. These are crossed by minor faults trending in a more southerly direction. The general effect of the movement has been to raise the strata on the north about 100 feet. West of the Duquoin anticline however, the displacement is reversed and the up-throw is on the south, as expressed in the Campbell Hill anticline.

In its effect upon mining this structural irregularity is of more importance than either the Duquoin or LaSalle anticlines because at least ten large mines are located in the belt of disturbance.

ILLINOIS OZARKS

The southern margin of the main coal basin south of the localities of mining is affected by folding and faulting. The structure brings to the surface Pottsville sandstones and shales which, because of their resistant character, produce a rough hilly country. In the southern, hilly, Pottsville region there are thin beds of coal of little value except in Eagle Valley. This valley is a small area within the hilly belt in Gallatin and southeastern Saline counties, where Carbondale strata are present and coals Nos. 2, 5, and 6 occur in workable thickness and extent. The relatively great amount of folding and differential pressure to which these coals have been subjected has improved the quality so that their heating value is higher than that of all other coals in the State. Unfortunately, however, Eagle Valley is remote from markets and has thus far been comparatively inaccessible, so that mining has not developed in this area.

CHAPTER III—ILLINOIS COAL RESOURCES AND THEIR FUTURE

ESTIMATES OF COAL RESOURCES

The following estimates have been made of the coal producing area of Illinois:

	<i>Square Miles</i>
M. R. Campbell ¹	35,600
A. Bement ²	37,486

The following estimates have been made at various times of the original coal resources of Illinois:

	<i>Tons of coal</i>
F. W. DeWolf ³	136,960,000,000
M. R. Campbell, first estimate ¹	240,000,000,000
M. R. Campbell, second estimate ¹	^a 201,454,584,320
A. Bement ⁵	201,399,808,000
Average.....	190,279,552,000

^a Original estimate was stated as 182,758,400,000 metric tons; it is here given in short tons for purposes of comparison.

The fourth estimate, made in 1908, is given in detail in Table 2.

TABLE 2.—*Estimate of Illinois coal areas and original resources^a*

Thickness of coal	Area	Coal largely proved	Coal not proved but probably present
<i>Feet</i>	<i>Square miles</i>	<i>Tons</i>	<i>Tons</i>
9	674	6,211,584,000	
7	3,883	27,833,344,000	
6	674		4,141,056,000
4	12,546	51,388,416,000	
4	3,883		15,904,768,000
3	10,184	31,285,248,000	
3	12,546		38,541,312,000
1.5	10,199	15,665,664,000	
1	10,184		10,428,416,000
	Total	132,384,256,000	69,015,552,000
	Grand Total	201,399,808,000	

^a Bement, A., Estimate made in 1908, based on measurements from maps on the scale of one-half inch to the mile and recompiled from tables 3 and 4, Illinois Coal Field: Illinois State Geol. Survey Bull. 16, p. 190, 1910.

¹ Campbell, M. R., and Parker, E. W., Coal fields of the United States: U. S. Geol. Survey Bull. 394, p. 19, 1909.

² Bement, A., The Illinois coal field: Illinois State Geol. Survey Bull. 16, p. 190, 1910.

³ DeWolf, F. W., Coal resources of Illinois: Am. Inst. Mining Engineers Bull. 24, pp. 1103-1112, 1908.

⁴ Campbell, M. R., Coal resources of the world: 12th International Geol. Congress, 1913.

⁵ Bement, A., op. cit., p. 189.

The estimates of tonnage of coal from 3 to 9 feet thick for the areas where the coal is largely proved (see Table 2) are probably as nearly accurate as could be made in 1908 with the data then available. More recent investigations, however, have shown that coals occur over more extensive areas and in greater thickness than was then known.

For instance it is now known that No. 6 coal has a greater thickness in Franklin and Jefferson counties than was previously assumed. In Franklin County it reaches a thickness of 14 feet (frontispiece). Furthermore, the seam has been proved continuous over a much larger area lying east of the Franklin County field than was included in the 1908 estimate of resources. The proved area of No. 5 coal in Saline, Williamson, and Franklin counties has also been greatly extended and there is increasing probability that both No. 5 and No. 6 seams in workable thicknesses are present much farther north in Hamilton and Wabash counties than there was evidence for assuming 20 years ago. At Lovington, in Moultrie County, a seam 8 feet 4 inches thick, worked at a depth of 904 feet, has been identified as No. 6 coal, although the blue band, a characteristic feature of this seam, did not appear in the original diamond-drill prospect boring. This locality is about 35 miles northeast of the town of Pana in Christian County, where the No. 6 seam occurs at a depth of 720 feet and is 8 feet thick. The uniformity of thickness and the persistence of this seam throughout explored areas gives strong presumption to the probability that the seam is more extensive in this general locality than was once believed.

In the northern portion of the field, in territories where seams Nos. 2 and 5 are widespread, thick bodies of coal of only local occurrence have been found. An extensive area of this character, located in LaSalle County and extending into Livingston County, has been mined out at Streator. Shafts sunk to the No. 2 seam at Cherry, Bureau County, and at Cardiff, Kankakee County, passed through thick bodies of coal that were mined together with the No. 2 seam. A 10-foot body of coal occurring in the upper Coal Measures was penetrated in drilling a well at Verona, Grundy County. Inasmuch as such bodies of coal were not considered in the original estimate for areas where coal is largely proved, the figures for this estimate were undoubtedly too low.

The estimate for unproved areas may be too high, but if so it is probably more than compensated for by too low estimates for the proved areas. A round figure of at least 200,000,000,000 tons of coal may be regarded as a reasonable estimate of the original coal resources of the State.

TABLE 3.—*Original and present available resources of the trade districts (1930)*

District	Coal Seam to which estimate applies	Square miles	Millions of Tons				Percentage of	
			Coal per square mile	Original Resources	Coal mined	Deple- tion	Coal remaining	Recovery ^a Depletion
1. Wilmington.....	2	270	3.30	891	48	51	840	95 5.7
2. Third Vein (LaSalle).....	2	1067	3.85	4,108	144	152	3,956	95 3.7
3. Fulton-Peoria.....	5	1356	4.95	6,702	130	277	6,425	47 4.1
4. Springfield.....	5	1184	6.60	7,814	140	280	7,534	50 3.6
5. Grape Creek.....	6	99	6.60	653	109	191	462	57 29.2
6. Central Illinois.....	6	4776	7.70	36,775	874	1,748	35,027	50 4.7
7. Centralia.....	6	241	6.60	1,590	33	60	1,530	55 3.7
8. Franklin-Wil- liamson.....	6	884	9.90	8,751	436	928	7,823	47 10.6
9. Big Muddy.....	2	.....	.....	.....	.....	.....	.....	.. 100.0
10. Saline County.....	5	270	5.50	1,485	104	193	1,292	54 12.9

^a Allen, C. A., Coal losses in Illinois: Illinois State Geol. Survey, Coop. Min. Ser. Bull. 30, 1925.

COAL DEPLETION

The State Department of Mines and Minerals reports that of the original resources 2,041,691,288 tons were mined in the period 1882 to 1930 inclusive, and that the government estimate for coal mined from 1833 to 1882 is 73,341,123 tons, which gives a total production of 2,115,032,411 tons.

On the basis of the above figures and a 50 per cent recovery the entire field has been depleted by 4,230,064,822 tons, or only 2.1 per cent. However, as mining for a long time will be confined to the trade districts shown in figure 9, mining in these districts is the problem of present concern. Table No. 3 gives an approximate measure of available resources, applied to what may be considered the immediate as distinct from the remote future.

From this table it appears that depletion outside of the southern Illinois territory (excepting Grape Creek and Big Muddy Districts) is between 3.5 and 5 per cent, whereas in the newer districts of southern Illinois depletion is 10 and 12 per cent. In District No. 8 depletion is 10.6 per cent, notwithstanding the fact that Franklin County has come into production only in recent years and that thus far Jefferson County has produced comparatively little coal.

The situation, as applied to Williamson and Franklin counties, is shown by the figures in Table 4.

TABLE 4.—*Depletion of coal in Williamson and Franklin counties*

County	Square miles	Millions of Tons					Percentage of	
		Coal per square mile	Original resources	Coal mined	Depletion	Coal remaining	Recovery ^a	Depletion
Williamson..	185	8.80	1,628	210	389	1,239	54	23.8
Franklin....	385	11.00	4,235	224	533	3,702	42	12.6

^a Allen C. A., Coal losses in Illinois: Illinois State Geol. Survey Coop. Min. Ser. Bull. 30, 1925.

If it is assumed that Williamson County for the next twenty years will average 8,000,000 tons a year, the production for the period will be 160,000,000 tons; and depletion of 296,300,000 tons plus previous depletion will give a depletion by the year 1950 of 682,300,000 tons, or about 42 per cent depletion by that time.

CONDITIONS AFFECTING COAL RECOVERY

Recovery in trade districts Nos. 1 and 2 is about 95 per cent. In other districts where the room-and-pillar method of mining is practised, recovery is sometimes as high as 60 to 70 per cent, but in every district there are areas that are not mined. For example, coal is seldom mined from under a cemetery, and generally it is not mined under towns or cities. There are also many places where the original owners of the coal for various reasons refuse to sell or lease to mining companies engaged in gathering a field. These areas are usually small, they become surrounded by operated territory, and are left when the mine is worked out. As they are too small to justify separate operation they remain unmined. For several reasons unworked territory is often left in mines and separating mines. A 50 per cent recovery may therefore be considered an average figure for those trade districts in which the room-and-pillar method is used.

CONCENTRATION OF PRODUCTION IN SOUTHERN ILLINOIS

It was not until about the year 1907 that coal users began seriously to consider southern Illinois as a source of supply. By 1925 Williamson, Franklin, and Saline counties produced 41 per cent of the State's output, an increase of 380 per cent over that of 1907, accompanied by diminished production in all other districts. It appears probable that coal production from southern Illinois will continue to increase and that there will be a corresponding decrease in other districts. However, the more concentrated the production in southern Illinois the shorter will be the life of the southern territory and the sooner will production be restored to the districts which are now being abandoned, but which sometime in the not very remote future will again be valuable property.

This is probably not a matter of critical interest to the general public but it should be a matter of concern to those industrial organizations who must consider adequate fuel supplies for their future. Corporations such as railroads or public utilities, which are permanent institutions, are justified in providing for the future, and a number of such corporations have acquired coal lands, particularly in Central Illinois District. Production from such properties for the year 1925 was as follows:

TABLE 5.—*Production from corporation mines in the Central Illinois District in 1925*

County	Tons Produced	
	Corporation Mines	County Total
Christian.....	3,380,431	3,823,214
Macoupin.....	4,410,885	6,213,109
Montgomery.....	1,444,375	2,156,726
Jackson.....	800,651	1,497,263

RESOURCES AND THEIR FUTURE

In 1925 the output from these properties together with that from similar mines in counties other than those of southern Illinois, was 14,170,020 tons. Production for that year from all shipping mines in the State was 64,180,414 tons. Subtracting the output of corporation mines, the production of what may be classed as strictly commercial mines was 50,010,394 tons. Of this the 27,000,000 tons from Southern Illinois District forms 54 per cent. A portion of the product of corporation mines finds an outlet in the commercial market in the form of larger sizes, 6 by 3 or 3 by 2 inches. Corporations which use stoker fuel and sell some of the larger coal have a lower cost stoker fuel than they would have if the larger coal were crushed. Much of the coal is necessarily crushed, however, because the market for the large coal is restricted.

If the management of some of these corporations should decide as a measure of economy to buy coal produced in southern Illinois and hold their fields as a reserve for the future, this would be a considerable factor, in addition to the present increasing demand, in curtailing the life of the southern field.

CHAPTER IV—COAL PRODUCING DISTRICTS

TOTAL PRODUCTION BY DISTRICTS

The Illinois coal field is divided into ten trade districts, as outlined in figure 9, page 23. The part played by the districts in the coal industry of Illinois has varied notably from time to time. The total production for each district from 1881 to 1930 is given in Table 6.

TABLE 6.—*Total production by trade districts*
1881-1930^a

District	Coal No.	Production in tons
1 Wilmington	2	48,316,663
2 Third Vein (LaSalle)	2	144,207,658
3 Fulton-Peoria	5	130,592,256
4 Springfield	5	140,672,436
5 Grape Creek	6	109,926,849
6 Central Illinois	6	874,729,287
7 Centralia	6	33,107,484
8 Franklin-Williamson	6	436,510,371
9 Big Muddy	2	29,000,000
10 Saline County (Saline-Gallatin)	5	104,376,173

^a Computed from compilation of the coal reports of Illinois, 1882-1930: Dep't Mines and Minerals, p. 16, 1931.

TOTAL PRODUCTION BY COUNTIES

In order that the reader may review the history of production by counties in the order of tonnage the data have been assembled in Tables 7 and 8. Table 7 shows the total production by counties for the period 1881-1930, listed both alphabetically and by rank.

TABLE 7.—*Total production from Illinois counties 1882-1930 inclusive^a*

ALPHABETICAL ORDER			ORDER OF TONNAGE		
County	Total Tons	Rank	Rank	County	Total Tons
Bond	6,536,721	32	1	Franklin	224,503,106
Bureau	46,268,256	14	2	Williamson	210,779,985
Cass	200,135	50	3	Sangamon	183,535,854
Christian	77,669,381	9	4	Macoupin	173,985,244
Clinton	32,720,868	19	5	St. Clair	153,043,660
Edgar	177,459	51	6	Madison	117,257,007
Franklin	224,503,106	1	7	Vermilion	109,926,849
Fulton	66,458,445	11	8	Saline	101,361,807
Gallatin	3,015,366	37	9	Christian	77,669,381

ALPHABETICAL ORDER			ORDER OF TONNAGE		
<i>County</i>	<i>Total Tons</i>	<i>Rank</i>	<i>Rank</i>	<i>County</i>	<i>Total Tons</i>
Greene	466,076	47	10	Perry	68,711,924
Grundy	37,739,265	17	11	Fulton	66,458,445
Hancock	281,454	48	12	Montgomery	61,718,866
Henry	5,953,806	33	13	LaSalle	59,354,000
Jackson	41,730,547	16	14	Bureau	46,268,256
Jefferson	1,227,280	42	15	Peoria	44,159,181
Jersey	102,041	53	16	Jackson	41,730,547
Johnson	236,847	49	17	Grundy	37,739,265
Kankakee	1,951,778	41	18	Marion	33,107,484
Knox	2,984,499	38	19	Clinton	32,720,868
LaSalle	59,354,000	13	20	Randolph	31,350,133
Livingston	9,874,199	27	21	Mercer	14,641,853
Logan	13,343,640	23	22	Tazewell	13,695,779
Macon	9,516,334	29	23	Logan	13,343,640
Macoupin	173,985,244	4	24	Marshall	12,401,103
McDonough	2,483,744	39	25	Menard	11,531,386
McLean	5,534,589	34	26	Washington	10,921,685
Madison	117,257,007	6	27	Livingston	9,874,199
Marion	33,107,484	18	28	Putnam	9,587,284
Marshall	12,401,103	24	29	Macon	9,516,334
Menard	11,531,386	25	30	Will	8,625,620
Mercer	14,641,853	21	31	Woodford	6,722,816
Montgomery	61,718,866	12	32	Bond	6,536,721
Morgan	160,236	52	33	Henry	5,953,806
Moultrie	2,032,236	40	34	McLean	5,534,589
Peoria	44,159,181	15	35	Shelby	3,869,507
Perry	68,711,924	10	36	Rock Island	3,316,475
Putnam	9,587,284	28	37	Gallatin	3,015,366
Randolph	31,350,133	20	38	Knox	2,984,499
Rock Island	3,316,475	36	39	McDonough	2,483,744
St. Clair	153,043,660	5	40	Moultrie	2,032,236
Saline	101,361,807	8	41	Kankakee	1,951,778
Sangamon	183,535,854	3	42	Jefferson	1,227,280
Schuyler	810,608	44	43	Stark	1,037,376
Scott	579,692	45	44	Schuyler	810,608
Shelby	3,869,507	35	45	Scott	579,692
Stark	1,037,376	43	46	Warren	566,255
Tazewell	13,695,779	22	47	Greene	466,076
Vermilion	109,926,849	7	48	Hancock	281,454
Warren	566,255	46	49	Johnson	236,847
Washington	10,921,685	26	50	Cass	200,135
Will	8,625,620	30	51	Edgar	177,459
Williamson	210,779,985	2	52	Morgan	160,236
Woodford	6,722,816	31	53	Jersey	102,041
Other counties...	1,923,551				
Total			2,041,691,288		

^a A compilation of the reports of the mining industry of Illinois from the earliest records to the close of the year 1930: Dep't of Mines and Minerals, p. 16, 1931.

COUNTY LEADERSHIP

Table 8 shows which county led in production for each of the years from 1881 to 1930 and shows the southward shift in production illustrated in figures 10-11 (pp. 24, 25) and 13-14 (pp. 27, 28).

TABLE 8.—*Counties leading in coal production, 1881-1930*

Chronological Order			Tonnage Order		
<i>Year</i>	<i>County</i>	<i>Tons</i>	<i>County</i>	<i>Year</i>	<i>Tons</i>
1881	LaSalle	624,900	Franklin	1926	15,741,550
1882	LaSalle	2,365,000	Franklin	1929	14,819,448
1883	Macoupin	1,233,200	Franklin	1928	14,078,932
1884	Macoupin	1,164,409	Franklin	1925	13,082,622
1885	St. Clair	1,202,549	Franklin	1923	12,845,459
1886	Macoupin	1,085,539	Franklin	1921	12,723,700
1887	LaSalle	1,125,235	Franklin	1924	12,240,925
1888	St. Clair	1,184,579	Franklin	1918	12,007,397
1889	Macoupin	1,202,187	Franklin	1930	11,997,347
1890	Macoupin	1,369,919	Franklin	1919	11,332,912
1891	St. Clair	1,595,839	Franklin	1917	11,317,657
1892	Macoupin	1,823,136	Franklin	1920	11,299,280
1893	St. Clair	2,133,870	Franklin	1927	10,360,881
1894	St. Clair	1,623,684	Franklin	1922	9,999,917
1895	Macoupin	1,948,992	Franklin	1916	9,070,811
1896	Macoupin	2,097,539	Williamson	1914	7,710,740
1897	Vermilion	2,000,623	Williamson	1913	7,709,110
1898	Sangamon	1,763,863	Franklin	1915	7,324,644
1899	Vermilion	2,221,867	Williamson	1912	7,086,554
1900	Sangamon	2,519,911	Williamson	1909	5,869,757
1901	Sangamon	2,919,223	Williamson	1910	5,858,413
1902	Sangamon	3,672,987	Williamson	1908	5,367,140
1903	Sangamon	4,386,526	Williamson	1907	5,266,452
1904	Sangamon	4,516,358	Williamson	1911	5,212,749
1905	Sangamon	4,395,050	Sangamon	1904	4,516,358
1906	St. Clair	4,168,019	Sangamon	1905	4,395,050
1907	Williamson	5,266,452	Sangamon	1903	4,386,526
1908	Williamson	5,367,140	St. Clair	1906	4,168,019
1909	Williamson	5,869,757	Sangamon	1902	3,672,987
1910	Williamson	5,858,413	Sangamon	1901	2,919,223
1911	Williamson	5,212,749	Sangamon	1900	2,519,911
1912	Williamson	7,086,554	LaSalle	1882	2,365,000
1913	Williamson	7,709,110	Vermilion	1899	2,221,867
1914	Williamson	7,710,740	St. Clair	1893	2,133,870
1915	Franklin	7,324,644	Macoupin	1896	2,097,539
1916	Franklin	9,070,811	Vermilion	1897	2,000,623
1917	Franklin	11,317,657	Macoupin	1895	1,948,992
1918	Franklin	12,007,397	Macoupin	1892	1,823,136
1919	Franklin	11,332,912	Sangamon	1898	1,763,863
1920	Franklin	11,299,280	St. Clair	1894	1,623,684

TABLE 8—*concluded*

<i>Year</i>	<i>County</i>	<i>Tons</i>	<i>County</i>	<i>Year</i>	<i>Tons</i>
1921	Franklin	12,723,700	St. Clair	1891	1,595,839
1922	Franklin	9,999,917	Macoupin	1890	1,369,919
1923	Franklin	12,845,459	Macoupin	1883	1,233,200
1924	Franklin	12,240,925	St. Clair	1885	1,202,549
1925	Franklin	13,082,622	Macoupin	1889	1,202,187
1926	Franklin	15,741,550	St. Clair	1888	1,184,579
1927	Franklin	10,360,881	Macoupin	1884	1,164,409
1928	Franklin	14,078,932	LaSalle	1887	1,125,235
1929	Franklin	14,819,448	Macoupin	1886	1,085,539
1930	Franklin	11,997,347	LaSalle	1881	624,900

WILMINGTON DISTRICT

Although this district is called the Wilmington District the coal actually occurs to the west of that town. (See fig. 9, p. 23.) Parts of Will, Kankakee, Grundy, and Livingston counties are included. During early production coal from the No. 2 seam was shipped from Braidwood, Braceville, and Morris, and large amounts were sent to Chicago, sixty-five miles away. Notwithstanding the proximity to such an important coal-using center, conditions have so changed that shipment from the No. 2 seam of the Wilmington District has entirely ceased, although two small mines produce a little coal for local use.¹

The No. 2 coal in the Wilmington District averages about 3 feet thick, and early mining was by the longwall method. (See discussion of Third Vein [LaSalle] district for description of this method.) The first mining was by slopes along the outcrop and later by shafts, as mining moved back from the outcrop. Essentially all of the coal is removed in mining by the longwall system, but with the coal is hoisted a considerable amount of rock and dirt. This is dumped on the surface at the shaft where the accumulated debris forms a large mound. Many of these mounds, marking the sites of former mines, may be seen from the Chicago and Alton Railroad, and a few near Morris may be seen from the Rock Island Railroad. The spoil bank on the west side of Kankakee River at the Chicago and Alton Railroad bridge does not indicate a mine but was the site of a former coal washer. Other coal washing plants which obtained their water supply from abandoned mines were once operated in this district.

¹ Since this bulletin was prepared a coal stripping project has been started in the No. 2 coal seam west of Wilmington.

Only a comparatively small amount of the coal of this district has been mined; it is not worked-out, but is except for an important strip mine an abandoned field. Cost of production, as compared with the cost of working thicker seams, where the room-and-pillar method is used, is the chief reason for the decline.

The digging of a farm well resulted in the chance discovery of an isolated body of workable coal, probably coal No. 7, near Verona, Grundy County, about 1920. After the area of coal had been outlined by careful drilling, a modern mine was opened which since 1923 has produced some 2,116,405 tons of coal, practically exhausting the supply. Relatively low production costs and freight rates favored the operation of the mine.

Table 14, page 105, shows the average quality of coal from this district.

THIRD VEIN (LaSALLE) DISTRICT

Portions of LaSalle, Bureau, Putnam, Marshall, Woodford, and Livingston counties are included in this district—an extensive territory in which the No. 2 coal seam is uniformly present at a thickness of 3 to 3½ feet. Although this coal bed is the same as that in the Wilmington district the two areas are separated by the LaSalle anticline, as described in Chapter II, and have always been recognized as distinct trade districts. The outcrop of the coal to the east of the city of LaSalle early invited mining and the first shaft in the district was sunk at the city. In those days, territory was not prospected by drilling; instead the shaft was sunk until it reached coal, which may have been No. 6 or No. 7. This seam was mined for a time, then the shaft was sunk to No. 5 coal and still later to the No. 2 coal. These coals were called the first, second, and third “veins.”

The No. 2 seam is reached by shafts from 300 to 465 feet in depth, depending on the elevation of the surface from which the shaft is sunk, the deeper ones being located on the higher ground away from Illinois River. Just east of the city of LaSalle the anticline so elevated the seam that the coal is present only in the tops of hills south of Illinois River, although at LaSalle it lies some 500 feet lower.

The longwall method of mining in the Third Vein and Wilmington districts is quite different from the room-and-pillar method practised in the thicker coal seams in other portions of the State. (See fig. 17.) In opening a mine under the longwall system a sufficient block of coal is left to support the shaft and plant (fig. 18) so that they will not be affected by settling of the ground. From this central point the coal is mined out in an ever-increasing circle, with passageways leading from the shaft to the face of the coal at convenient intervals. As the removal of the coal does not provide enough head-

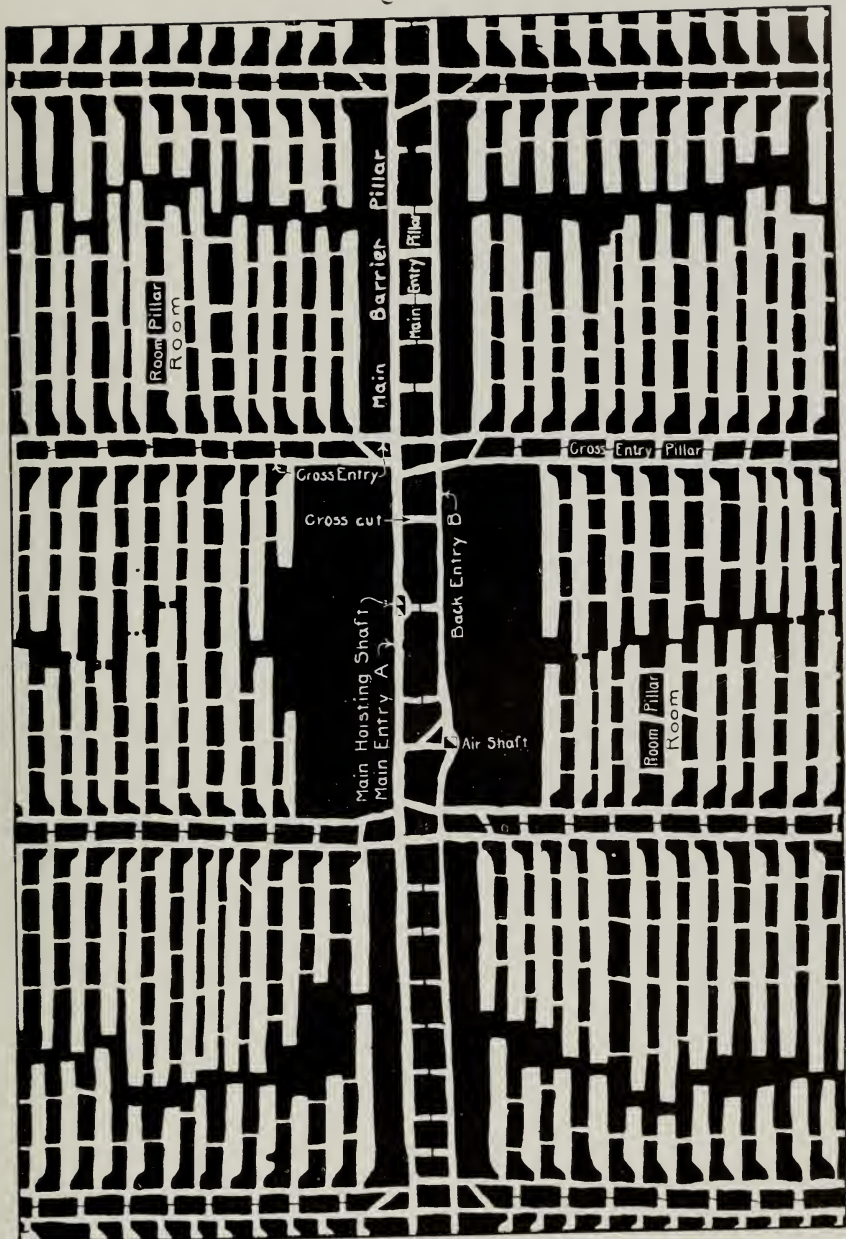


FIG. 17. Plan of room-and-pillar mine

room, it is increased by removing with hand-pick some of the overlying strata along the entries or roadways. The coal is also undercut by hand-pick in the fireclay below. The shale taken down in extending the entries and the under-cuttings from the clay are used to build up a pack wall a few feet behind the coal face to prevent undue settlement of the overlying strata. These pack walls

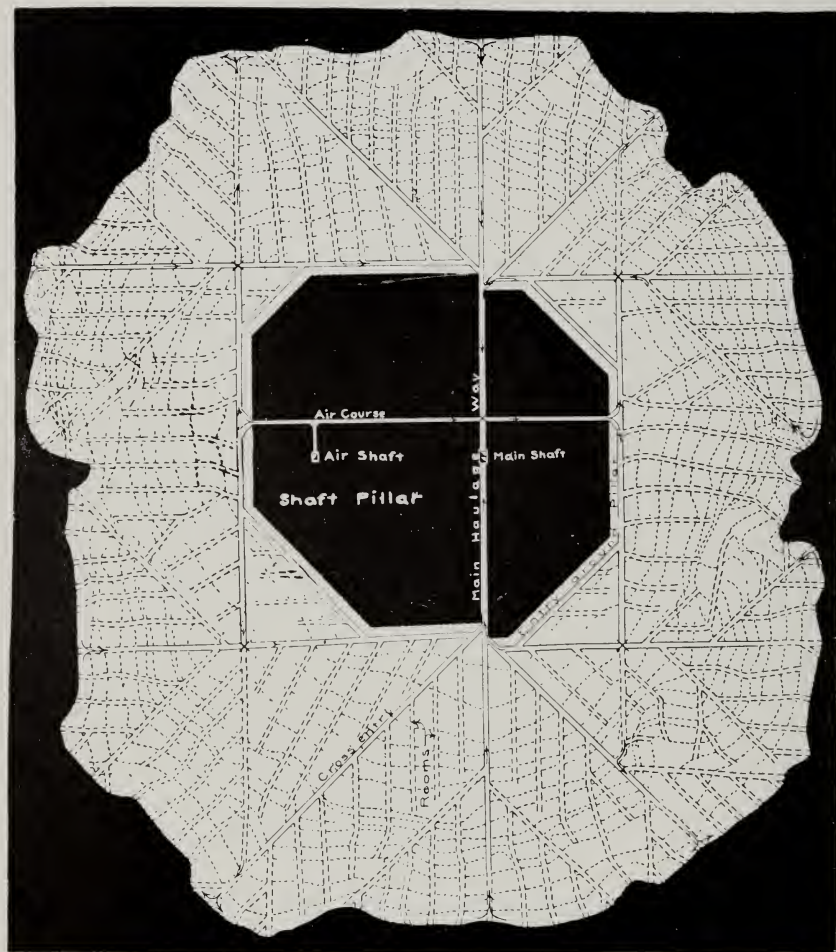


FIG. 18. Plan of longwall mine.

do not entirely prevent subsidence, for during the night enough pressure is exerted on the undercut coal to break it down so that when the miners arrive in the morning the coal is ready to be loaded out. In this manner the continuous face of coal, or longwall as it is called, moves out in a constantly widening circle, with the spaces behind, except the entries, filled to support the roof.

By this method nearly all the coal is removed, and although the seam may be only $3\frac{1}{2}$ feet thick the production per acre is as much as from a seam 7 feet thick mined by the room-and-pillar method with half of the coal left underground. Practically all the No. 2 coal has been mined from beneath LaSalle since the city was built. Due to the fact that so much of the coal is recovered in these northern fields they have occupied a notable position with respect to conservation of natural resources.

From the standpoint of economy of operation these fields occupy a less notable position. Inasmuch as all the coal is removed, and as the packing material used to replace it is smaller in bulk, there is eventually permanent settling of the overlying strata. The packing serves to temporarily support the roof as mining progresses but eventually subsidence tends to close the passage-



FIG. 19. A mound of refuse from the Longwall system of mining in the Third Vein (LaSalle) district.

ways leading from the shaft to the coal face. These must be kept open to the proper height, so shale from the roof of the passageways above is removed, and together with that which falls, is loaded into mine cars and dumped at the surface, gradually forming large refuse mounds (fig. 19). In general about 20 per cent of the cars hoisted are loaded with material which goes to the dump. The expense of handling this waste material and the amount of labor required results in a cost of production higher than in the room-and-pillar mines in the other districts of the State.

The mining plants in the Third Vein District were the best in Illinois in their day. Figure 20 shows a general type. This particular view is of the

Spring Valley Mine No. 5, which has since been dismantled, but when it was opened, about twenty years ago, it was the best equipped plant in the State.

It seems reasonable to expect that this district, as well as the Wilmington District, eventually will again become an important coal producing area.

Table 14, page 105, shows the average quality of coal from this district.

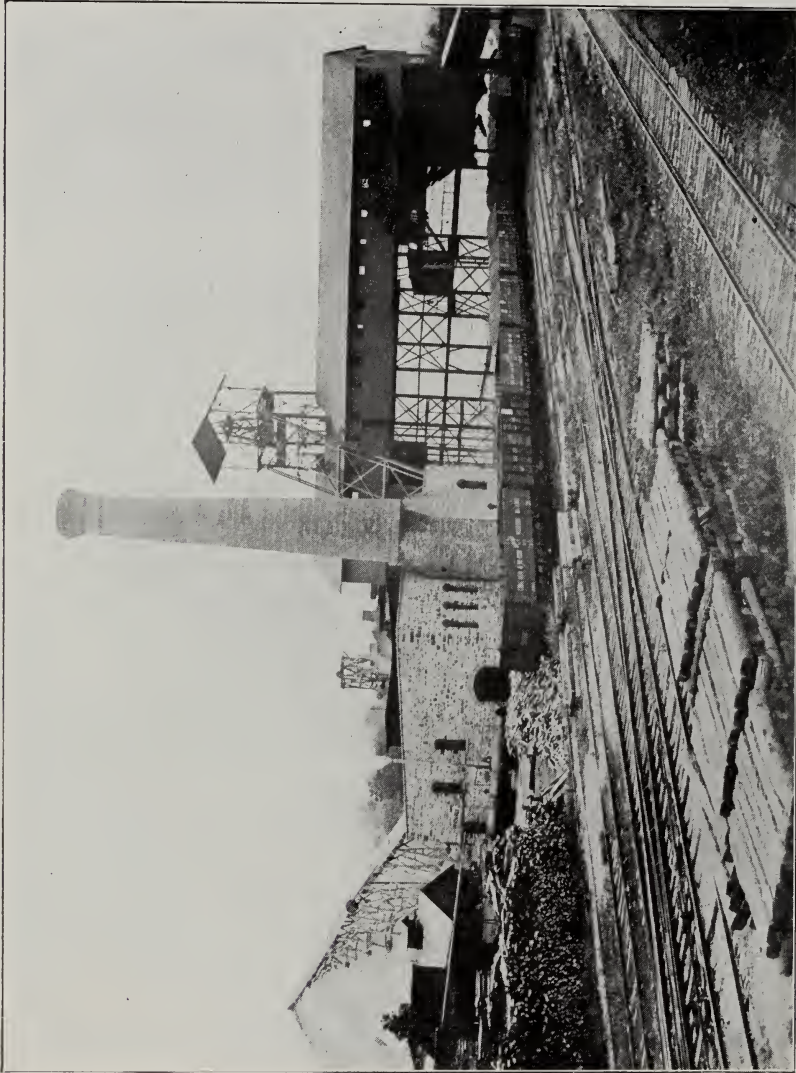


FIG. 20. Tipple of Spring Valley Mine No. 5, formerly one of the largest mines in the State, now dismantled.

FULTON-PEORIA DISTRICT

This district is named from the two principal counties within its boundaries. Mining for shipment is practically all from the No. 5 coal seam,

which ranges from 4 to 5 feet thick. The coal is of medium thickness as compared with the thin coal of the Wilmington and Third Vein districts and with the thicker coals of the other districts. The room-and-pillar system of mining is employed.

Cost of production is somewhat higher than in thicker coal territories, due in considerable measure to the presence of "clay veins" or "horsebacks" which extend into or through the coal seam. (See fig. 21.) These veins are clay filling in fissures; the clay has become hardened but not sufficiently to be designated as rock by the miner. They contribute in some measure to the ash content of mine run coal and screenings.

In past years a large number of mines in this district shipped coal to Iowa and points northwest, as well as to adjacent territory, but production in the district is rapidly declining.

Table 14, page 106, shows the average quality of coal from this district.



FIG. 21. "Horseback" or vein of clay in No. 5 coal seam, in the Springfield District.

SPRINGFIELD DISTRICT

The No. 5 coal seam is mined in this district, which comprises parts of the counties of Logan and Menard and the northern portion of Sangamon County. The term "Springfield District" has been loosely employed, sometimes being used to cover most of the territory from Fulton to Perry counties. The fact that No. 5 coal is mined in northern Sangamon County and No. 6 in the southern portion of the county is considered justification for confining the district to the area underlain by the No. 5 coal. Although the seam is the same as that mined in the Fulton-Peoria District, the quality of the coal differs in these two areas, and as they are some distance apart they are recognized as distinct districts.

The coal seam in the district is quite uniformly 6 feet thick, with good roof and favorable mining conditions. The room-and-pillar method of mining is employed.

The coal seam contains the same sort of fissures found in Fulton and Peoria counties, but instead of being filled with soft clay they contain hard shale. It is too hard to contribute to dirt in the coal, but its occurrence interferes with systematic mining.

Production in this district has been at approximately the same rate for many years, as illustrated by figure 13 where its output is shown in combination with that from the No. 6 seam in the county.

Table 14, page 105, shows the average quality of coal from this district.

GRAPE CREEK DISTRICT

This is a comparatively small area south of the city of Danville, in Vermilion County. Its accessibility to market formerly enabled the district to take a prominent place in coal production. In 1897 and 1899 this county led all others in quantity of output, but in later years production has steadily declined.

There are two commercial beds in Vermilion County that have been tentatively correlated with coals Nos. 6 and 7 of other parts of the Illinois field, but in the Grape Creek District the bed which is being mined is the No. 6. This seam is about 6 feet thick.

Mining conditions are not of the best, as the strata over the coal do not afford a very good roof. The room-and-pillar system of mining is employed.

Table 14, page 105, shows the average quality of coal from this district.

CENTRAL ILLINOIS DISTRICT

This district comprises the largest part of the territory in central and southwestern Illinois in which coal definitely correlated as the No. 6 is mined. The No. 6 coal is mined in the Centralia District, but this area is isolated and the quality of the coal is different enough to justify considering it as a separate district. The No. 6 seam is also mined in Williamson, Franklin, and Jefferson counties, but as these counties are separated from the Central Illinois District by the Duquoin anticline, and as there are differences in the quality of the coal, this area is also considered as a separate district.

The coal seam in the Central Illinois District ranges from 6 to 8 feet thick; mining in most of the territory is in coal 7 feet thick. The usual overlying stratum is a soft gray shale, unsuitable for a natural roof over mine workings and for this reason the upper part of the coal seam is commonly left in place to form the roof. It is fortunate that this extensive coal body is

thick enough that a coal roof may be left, for under present market conditions the seam might not otherwise be workable. A thin "blue band" occurs in the lower portion of the coal, varying in thickness from an inch to three inches, and is separated from the coal in mining. This blue band is regarded as characteristic of the No. 6 seam.

Mining is by the room-and-pillar method, described briefly in the section devoted to the Third Vein District. The panel system is widely employed. In this system the territory is blocked off and in mining, these blocks, or panels,

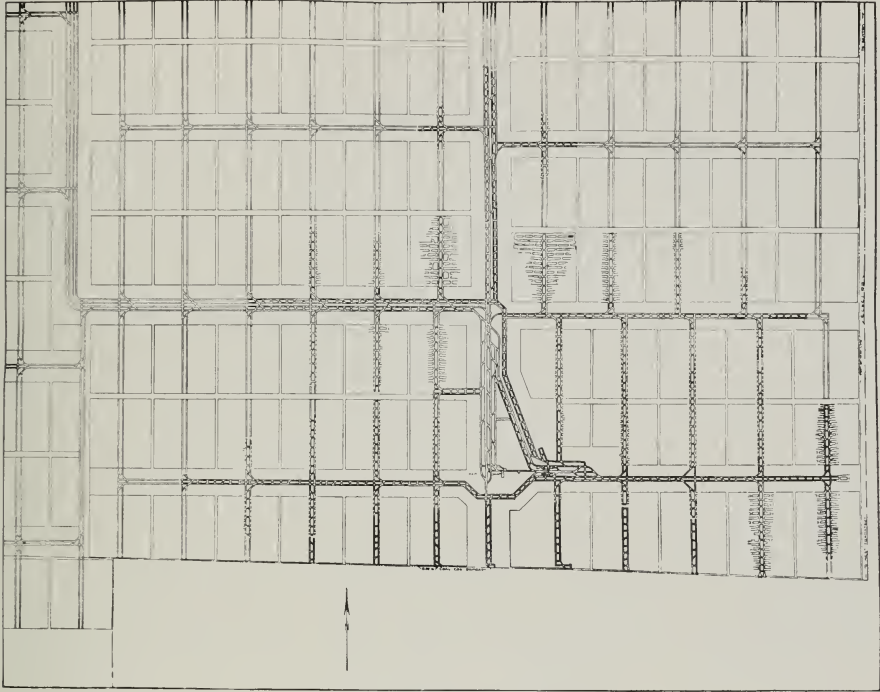


FIG. 22. Plan of panel mine

are protected by especially wide pillars. (See fig. 22.) In each panel are cut the usual passageways and rooms from which the coal is mined. The advantage of the panel system is that after a panel has been worked out it may be easily cut off, usually by brick walls, from other parts of the mine, thus saving the cost of ventilation and maintenance of airways in worked-out areas.

In the process of mining, the coal seam is undercut by a machine which cuts a space about four inches high and six feet back completely across the working-face (fig. 23). The support below the mass of coal to be blasted is thus removed so that the coal does not break up as much as it would if it were not relieved by the undercutting. After undercutting is done the machine is

removed from the room, and miners drill holes in the coal face and load them with explosive, ready for firing. After the miners leave the mine, which is about three o'clock in the afternoon, men especially employed to do the firing visit the rooms and light the blasts which dislodge the coal. In the morning such props are set as may be required to support the roof of the room and then the coal is loaded, as shown in figure 24, and the cars are removed by small electric locomotives which are termed gathering locomotives because they are used to gather the loaded cars from the rooms.

Trolley wire is not extended into the rooms; power is supplied to the locomotive when it enters the room by a cable carried on a reel mounted on the motor. The motorman in entering a room hooks the end of this power cable

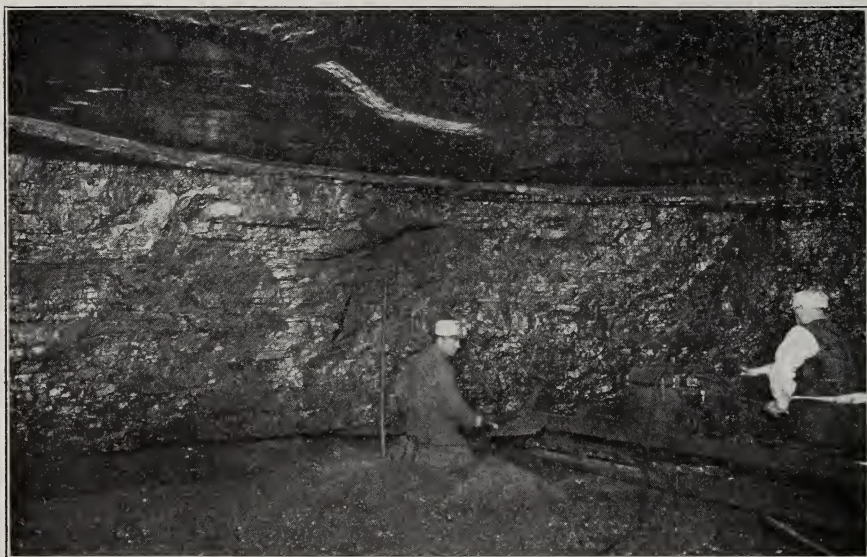


Fig. 23. Mining machine undercutting coal bed. By means of cutting bits carried on a link chain the coal seam is undercut for a distance of about six feet back and four inches high, the full width of the face. The cutting relieves the coal when it is shot down by explosives. The old method of undercutting the coal with a handpick was a very laborious operation.

to the trolley wire in the roadway, and as the motor moves forward the cable unrolls; as the motor moves out, the cable automatically winds up. When on haulage roads these motors get power direct from the trolley wire.

On railroads switch engines gather loaded cars from factories and assemble them at gathering points where they are made up into trains and then hauled by road engines. The gathering locomotive, or motor, is the switch engine of the coal mine. It gathers and distributes cars from certain

convenient assembly points to the various rooms in the district which it serves. The assembled trains are hauled to the shaft bottom (figs. 6a and 6b, p. 18) by larger electric locomotives (fig. 25). Upon arrival, the loaded cars are caged, clamped firmly, and hoisted to the tippie where the coal is weighed and screened for loading.

Production from the Central Illinois District has maintained a comparatively steady rate for many years. On the basis of its percentage of the State's entire output, however, it has steadily declined in recent years. Figures 13 and 14, illustrating the history of production in Sangamon County, also illus-



FIG. 24. Miners loading coal in room of mine

trate the status of Central Illinois District. A number of corporation-owned mines are operated in this district and they have been an important factor in maintaining the rate of production.

Table 14, page 106, shows the average quality of coal from this district.

CENTRALIA DISTRICT

This is a small district from which an important amount of coal was formerly shipped. Production, however, has declined in recent years. The No. 6 coal is mined by the room-and-pillar method.

The thickness and mining conditions are generally the same as in the Central Illinois District.

Table 14, page 105, shows the average quality of coal from this district.

FRANKLIN-WILLIAMSON DISTRICT

This district includes Franklin and Williamson counties and the southern half of Jefferson County, and lies east of the Duquoin anticline. (See fig. 9, p. 23).

Mining began in Williamson County by slope at the outcrop about the year 1883, and reached a production of a million tons for the year 1899. In



FIG. 25. Coal trains arriving at the vicinity of the bottom of the shaft. The electric locomotives are here disconnected from the train and switched off to other tracks to haul back empty cars.

1904 mining began in Franklin County, and by 1915 exceeded the output from Williamson County. Present production from Jefferson County began in 1925 when the Illinois Coal Corporation opened a mine at the town of Nason. In former years a mine was operated at Mt. Vernon, the county seat, but it is now abandoned. This old mine was located north of the thick body of coal where the seam is only 4 feet thick.

Mining is in the No. 6 coal. Figure 26 shows a mine which is being operated in this general locality. The general characteristics of the seam and overlying strata are similar to those of the Central Illinois District, except that the limestone cap-rock found in southwestern Illinois is absent in a large part of Franklin-Williamson District. The most characteristic feature of the

seam is the stratum of rock in the lower portion, known as the "blue band," ranging in thickness from about an inch to 3 or 4 inches, and which must be removed in mining.

The seam ranges in thickness from 8 to 10 feet over the greater portion of the district and reaches the maximum thickness of 14 feet in Franklin County. The bed extends across northern Williamson and Saline counties, though it is not mined in Saline County, and it ranges in depth from nothing at the outcrop to 720 feet at Nason, in Jefferson County.



FIG. 26. Surface equipment of a mine in Franklin County.

Where the seam exceeds 8 feet in thickness the overlying strata are such that the upper two feet of coal is left in place to form the mine roof, as in most mines in Central Illinois District. After the rooms of a panel have been mined off an attempt is commonly made to remove the upper bench of coal which may be 2 to 6 feet thick, but the amount of coal recovered is limited both by the difficulties and by the cost. Where the cost is higher than mining in new territory there is naturally a disposition to leave much of the roof coal in place in the abandoned territory. In eastern Williamson County, however, where the seam is 5 to 6 feet thick, the overlying strata form a good natural roof so that the seam may be mined to its full height.

From the standpoint of conservation of natural resources Franklin County does not occupy a creditable position. In the areas of thicker coal, resources may be as much as 400 per cent greater than in the 3½-foot coal area of the Third Vein District, but mining to a height of 8 feet, and with a 50 per cent recovery, the production per acre is only 30 per cent greater than in the Third Vein District. If the entire height of the coal were mined, and one half the coal left in pillars, the recovery would still be only twice that of the Third Vein District.

Though the thick coal seam is wastefully extracted the largest mines in the State, and one considered the largest in the world, are located in Franklin County. The extraordinary thickness of the coal seam allows mine workings of greater height, and therefore the use of larger mine cars than are feasible in thinner seams. On each trip the larger car carries correspondingly greater quantities of coal to be hoisted to the tippie, and inasmuch as the number of hoists made in a day are approximately the same in any mine, the use of the larger mine car is an appreciable factor in increasing the rate of production. This also applies to skip hoisting.

The initial development in Franklin County was made by Mr. Joseph Leiter, a well-known Chicago capitalist, who organized the Zeigler Coal Company. Mining began in the southern part of the county in 1904 and disclosed a coal seam of the unusual thickness of 12 feet. The occurrence of such an exceptionally thick seam attracted the attention of companies operating mines in other parts of the State and there was quite an exodus from older districts to Franklin County, resembling somewhat the rush to a new oil field. Some of the companies that followed Mr. Leiter into the field had long been engaged in the coal business, were familiar with coal users' requirements, and in planning equipment gave particular attention to the preparation of the coal, especially those sizes used in the domestic trade. These operators, with Mr. Leiter, took a leading position in the use of advanced methods of preparation and in developing a market for coal thus prepared.

In western Franklin County and adjacent parts of Jefferson and Williamson counties, as shown in figure 43, the sulphur content is less than 1.25 per cent, so that if otherwise suitable, the coal can be used for metallurgical purposes and for the manufacture of water gas and retort gas.

Table 14, page 107, shows the average quality of coal from this district.

BIG MUDDY DISTRICT

In this district, which lies within Jackson County, the No. 2 coal seam, 6 feet thick, occurred over much of the area. In the rest of the district the seam is separated by a rock parting into an upper and lower bed. Early mining in this district was carried on by two companies. The territory of one

of these companies included part of the area where the seam was split, and when workings extended into this area mining was abandoned. Final mining was done by other companies in the lower 4-foot bed. The coal took its name from Big Muddy River which flows nearby and down which, it is reported, the first shipment of Illinois coal was made in 1819.

During the life of this field the quality of its product was generally considered in the coal trade as the best Illinois coal in the market, and it usually commanded a higher price than that received for coal from other sources in the State. At one time two blast furnaces in the country used coke made in local ovens from the Big Muddy product, though the best coke used at Murphysboro is reported to have been made from a mixture of Big Muddy and Williamson County coal. It is probable that these furnaces were the first west of Ohio River to use coke for fuel instead of charcoal. Figure 43, page 91, shows that the sulphur content of coal in this district was less than 1.25 per cent.

This field was favorably located with respect to market, and production rose to a million tons per annum and then declined. The last remaining mine, in the No. 2 seam, owned by a public service corporation that produced coal for its own use, has now been worked out.

The No. 6 seam occurs in the county to the northeast of the Big Muddy District and above the Big Muddy coal and the present production in Jackson County from No. 6 seam has reached a million tons per year.

SALINE COUNTY DISTRICT

Mining in the Saline County District is in the No. 5 seam instead of the No. 6 so that although the territory is a part of the Southern Illinois Field it is distinct from the Franklin-Williamson District. It has sometimes been designated as the Saline-Gallatin District, though not more than two small mines have shipped coal from Gallatin County. In 1925 but one mine produced coal for shipment and it loaded only 20,276 tons. Discussion of Gallatin County and the remote Eagle Valley locality are included in Chapter II on the geology of the Illinois Coal Field, not because of importance from the standpoint of production, but for scientific reasons. Figure 5, (p. 17) shows a type of mine operating in this district, and figures 6a and 6b (p. 18) show the shaft bottom from both the loading and empty car sides.

The No. 5 coal ranges in depth from nothing at the outcrop to about 800 feet at the northwest portion of the county. In thickness it varies from 8 feet to a seam too thin for mining in certain restricted areas. Mining is in coal from 5 to 6 feet thick. This coal in physical character and heat value more nearly resembles coal of the eastern fields than any other coal now being mined in Illinois. The room-and-pillar system of mining is employed.

The overlying strata are generally gray or black shale and roof conditions are excellent so that the seam is mined to its full height. The underlying stratum is fireclay or sandy shale of unusually hard character for Illinois, either of which provides a good floor in the mine workings.

Saline County has produced coal in small amounts from an early period, but it was not until 1903, with the change of the Cairo Division of the Big Four Railroad to a coal-carrying railroad, that Saline County coal became available to general markets. The demand was such that production increased from about 320,000 tons in 1905 to 2,500,000 in 1908.² The principal buyers were users of steam coal. Beginning a few years before the World War new mines were established with modern and adequate equipment for making all grades of prepared coal for domestic and other uses. At the same time a number of the older mines were considerably improved.

This county, together with Franklin and Williamson counties, may be considered a new field of recent development. All the new large mines which produce commercial coal are in these three counties. Modern mines established in the Central Illinois District during the same period belong to corporations that are producing coal for their own use.

The superior heat value of this coal and the improvement of transportation facilities have been important factors in bringing about the rapid development of this district. Use of the coal has been extended successfully to gas manufacture in plants where proper purifying capacity is available. The average quality of the coal from this district is shown in Table 14, page 107.

OTHER COAL PRODUCING AREAS

In addition to the ten general trade districts there is, or has been, mining in other localities, described below.

PERRY COUNTY

In Perry County, lying along the crest of the Duquoin anticline, is a long, narrow, north-south area in which the No. 6 coal is of a quality intermediate between that in Franklin County and that to the west of the anticline. Several mines are worked in this area and the product sometimes competes in the market with coal from Franklin County. In former years coal was shipped from a number of small slope-mines in the exposed seams.

An off-set of the line of outcrop of No. 6 coal in this area was originally interpreted as evidence of two coal beds; the southern was regarded as No. 6 and the northern, thought to belong above No. 6, was called No. 7. It has since been discovered that the northward shift in the line of outcrop was due to displacement which accompanied folding along the anticline, and the continuity of No. 6 coal has been established.

²Coal Report: Dep't Mines and Minerals, p. 370, 1905; p. 91, 1908.

VERMILION COUNTY

A bed 5 feet thick, known as the No. 7 seam, occurs in Vermilion County west of the city of Danville and northwest of the Grape Creek District. This coal has been mined by strip mining and small shaft or slope mines for many years. It is generally known as Danville coal and has but a limited market.

ROCK ISLAND AND MERCER COUNTIES

In former years an important amount of coal was produced from a long narrow area in Rock Island and Mercer counties. The coal body mined was considered to be the No. 1 seam, and the prospected area has been exhausted. There is possibility, however, of unprospected areas remaining.

LIVINGSTON COUNTY

Formerly coal was mined near the city of Streator, in Livingston County, in an area which also extended a little way into LaSalle County. The seam, called No. 7, was unusually thick but the roof conditions were not very good. There are a few large mounds in the territory similar to dumps from the longwall method of mining, but here the room-and-pillar system was employed and the dumps represent the hoisted refuse from roof-falls and other sources. This mining was within the area of the Third Vein District, but the No. 2 seam was never mined extensively. The one attempt made to mine No. 2 coal failed because of unfamiliarity with the requirements of longwall mining.

CHRISTIAN COUNTY

The deepest bituminous coal mine in the United States is located at the town of Assumption, north of the city of Pana, in Christian County. The shaft, 1020 feet deep, reaches what is considered the No. 1 coal seam. Until recently that seam has been mined together with one considered the No. 2 seam. Production has never been large but the output for many years commanded an excellent market.

MOULTRIE COUNTY

At the town of Lovington, in Moultrie County, a shaft reaches a coal body about 8 feet thick, considered the No. 6 seam, at a depth of 904 feet. This mine was formerly important but is not now operated.

MCLEAN COUNTY

At Bloomington, in McLean County, there is a deep shaft³ in which the No. 2 seam is now mined, though formerly both No. 5 and No. 2 seams were

³ This mine was abandoned in 1929.

worked. This is the largest mine in the State that produces coal for local consumption. None of the coal is shipped, and practically all of it is marketed in the city.

MACON COUNTY

At Decatur, in Macon County, there are two important shaft mines in coal No. 5 that supply a portion of the local demand.⁴

HENRY COUNTY

At Alpha, in Henry County, there is a shaft to Coal No. 1 from which a considerable amount of coal is shipped.

GRUNDY COUNTY

At Verona, in Grundy County, a new shaft reaches a body of coal about 10 feet thick, thought to be No. 7. About 2,000,000 tons of coal have been shipped from this mine since it opened in 1924.⁵

⁴ One of these mines was abandoned since 1929.

⁵ This mine was worked out and abandoned in 1930.

CHAPTER V—COAL MINING IN ILLINOIS

MINE OPENINGS

With a few exceptions which apply mostly to strip mines, all mines now shipping coal by rail are reached by vertical shafts, but the first mining in Illinois was along outcrops, and the coal was reached by inclined slopes. The early developments were in localities where coal seams sufficiently thick for mining were exposed at the surface. Such localities are indicated below.

Seam No. 1—Rock Island County, on the bank of Rock River.

Seam No. 2—Grundy, Will, and LaSalle counties; in a number of the western counties (mined for local market); and Jackson County, on the bank of Big Muddy River.

Seam No. 5—Fulton, Peoria, Saline, and Gallatin counties.

Seam No. 6—St. Clair, Williamson, and Perry counties. In the last county, because of irregularities caused by the Duquoin anticline, two beds were thought to occur and No. 6 coal was in some places called No. 6 and in other places No. 7.

Seam No. 7—Vermilion County, on branches of Vermilion River.

There are a large number of very small slopes and drifts in the western counties in various seams, and a few occur in some of the interior counties where there is a small production for local use.

The early shipping mines were adjacent to river transportation, but these were largely abandoned at an early date for operations located along railroads.

DEPTHS OF SHAFTS

Depths to the different seams at shafts vary as follows, though some of the mines for which figures are given are no longer operated.

Coal No. 1, or the seam so designated, ranges from an outcrop in Rock Island to a depth of 1020 feet in a mine at Assumption in Christian County.

Coal No. 2, in Grundy, Will, and Kankakee counties, has been mined in shafts ranging in depth to 200 feet. In the Third Vein (LaSalle) field the depths of shafts range from 300 to 465 feet, depending on the surface elevation.

Coal No. 5, mined by shafts in Fulton and Peoria counties, varies in depth to 196 feet. In the Springfield district, counties of Sangamon, Menard, and Logan, shafts are as deep as 250 feet; present mining is practically all at

TABLE 9a—Comparison of mine production for 1908 and 1925

Type of mine	Number of mines			Production in tons				Maximum mine production		
	1908		Per cent ^a	Total		Average		1908	1925	Per cent ^a
	1908	1925		1908	1925	1908	1925			
Shipping	407	255	—37	47,809,730	64,180,414	+34	251,688	566,670 (5 mines produced more than 500,000 tons)	1,473,701 (9 mines produced more than 1,000,000 tons)	+160
Commercial Corporation	393	221	—44	43,593,612	50,010,394	+15	226,291	110,925	416,765	+104
	14	34	+143	4,216,118	14,170,020	+236	301,151	301,151	416,765	+38
Room-and-pillar	362	221	—39	42,257,302	59,919,547	+42	116,733	271,129	133	+133
Longwall	45	16	—64	5,552,428	1,207,144	—78	123,387	75,447	—39	—39
Stripping	....	18	....	.....	3,053,723	....	.....	169,651	600,000	+37
Local	515	658	+218	1,462,722	1,994,071	+36	2,840	3,031	37	+37
Grand Total	922	913	—1	49,272,452	66,174,485	+34	53,441	72,480	36	+36

TABLE 9b—Comparison of mine labor for 1908 and 1925

Type of mine	Tons mined			Number of men employed			Tons mined per man			Average number working days			Tons mined per man per day		
	1908		Per cent ^a	1908		Per cent ^a	1908		Per cent ^a	1908		Per cent ^a	1908	1925	Per cent ^a
	1908	1925		1908	1925		1908	1925		1908	1925				
Shipping	47,809,730	64,180,414	+34	67,470	77,620	+15	708.61	826.85	+17	191	139	—27	2.54	5.95	+60
Local	1,462,722	1,994,071	+36	3,371	4,064	+21	434.91	490.67	+43	171	139	—19	3.71	3.53	+39
Total	49,272,452	66,174,485	+34	70,841	81,864	+15	695.54	810.13	+16	190	139	—27	3.66	5.83	+59
(or average) ...															

^a In the per cent columns an increase is indicated by "+", a decrease by "—".

about that depth. In Saline County the depth varies from short shafts near the outcrop to 600 feet at Galatia in the northern part of the county.

Coal No. 6 is reached by shafts ranging from shallow depths to 722 feet at Pana in Christian County, 904 feet at Lovington in Moultrie County, and 725 feet at Nason in Jefferson County. Formerly a shaft at Mt. Vernon reached the coal at 860 feet.

Coal No. 7 has been worked at depths of from 15 to 208 feet, depending on the surface elevation.

MINE DATA

Tables 9a and 9b present data for the year 1925, to which, for the purpose of comparison, corresponding figures for 1908 are presented as applying to the period covered by the former bulletin on the Illinois Coal Field.¹

INTERPRETATION OF MINE DATA

The table shows three outstanding features: a decreased number of mines using the longwall method of mining; an increased mine production; and an increased number of mines operated by industrial or public service corporations producing their own coal.

The decrease in the number of mines using the longwall method of mining is due to inability to meet the competition of better coal produced at a lower cost.

In general, production per mine in 1925 had doubled that of 1908. The new Orient No. 2 mine, of the Chicago, Wilmington, and Franklin Coal Company, shown in figure 2, promises to surpass any single 1925 record. This mine has an elevating capacity of some 13 tons per hoist, which, at 1000 hoists per day would give a daily capacity of 13,000 tons. Assuming 240 working days in a year as a possible maximum, this would give a production of 3,120,000 tons, doubling the high record of 1925.

Of the nine mines producing more than a million tons each in the year 1925, five are located in the Central Illinois district and are operated by corporations producing their own coal; the other four are in the southern Illinois coal field. Many of these large mines have not only large production capacities, but their holdings insure long lives.

Prior to 1908 production of coal by corporations was carried on by only a few railroads and by three zinc industries. During the war, however, when supplies were so uncertain, a number of other corporations purchased existing mines and opened new ones. Some of these corporations use coal in the form of screenings in stoker-fired furnaces, but unless the large coal can be sold in the market it is necessary to crush mine run, a more expensive fuel than

¹ Illinois State Geol. Survey Bull. 16, 1910.

screenings. The crushing of mine run was economically justified during the war but thereafter the small demand for the larger coal made it necessary to crush mine run coal as a regular procedure. Such corporations have found their fuel cost much higher than it would have been had they been able to take advantage of the commercial fine-coal market.

COAL STRIPPING

The first coal stripping of any importance in Illinois was begun many years ago in Vermilion County, where on the branches of Vermilion River the No. 7 seam was overlain by thin cover. The original site of operation was known as the Mission field. Since that time stripping has been carried on more or less continuously at different locations in this territory. The view shown in figure 27 is of a recent stripping operation in the Middle Fork of Vermilion River Valley. Within the last five years a number of stripping projects have been in operation in southern Illinois along the line of outcrop of coal seams Nos. 5 and 6, in Fulton County near Cuba in the No. 5 seam, and recently in Grundy County, west of the town of Wilmington, in the No. 2 seam.²

Table 10 shows the counties in which coal is mined by this method, the seams stripped, the quantity and the percentage of the county output produced by this method in 1930.

TABLE 10.—*Production of coal by stripping in 1930^a*

County	No. of strip mines	Coal seam stripped	Tons produced		Per cent by strip mining
			Total	By strip mining	
Fulton	2	No. 5	1,634,772	885,249	54.1
Henry	1	No. 2	504,761	397,510	78.7
Jackson	2	No. 6	2,054,836	805,337	39.2
Livingston	1	No. 7	24,351	1,223	5.0
Perry	4	No. 6	3,309,648	2,251,321	68.0
Saline	2	No. 5	3,670,144	192,365	5.2
St. Clair	1	No. 6	2,447,784	275,320	11.2
Vermilion	2	No. 7	2,930,924	420,441	14.3
Will	1	No. 2	865,666	865,666	100
Williamson	10	Nos. 5, 6	4,107,573	181,535	4.4
State	26		54,035,116	6,275,967	11.6

^a Compiled from Forty-ninth Coal Report of Illinois, 1930: Department of Mines and Minerals, 1931.

² Since 1929 a large strip mine has been operated near Atkinson in Henry County.



FIG. 27. Airplane view of a recent stripping operation along the Middle Fork of Vermilion River Valley, Vermilion County.



FIG. 28. A modern electric shovel used in coal stripping. The boom is 90 feet long and the bucket has a capacity of 8 cubic yards. Note the comparative size of the men.

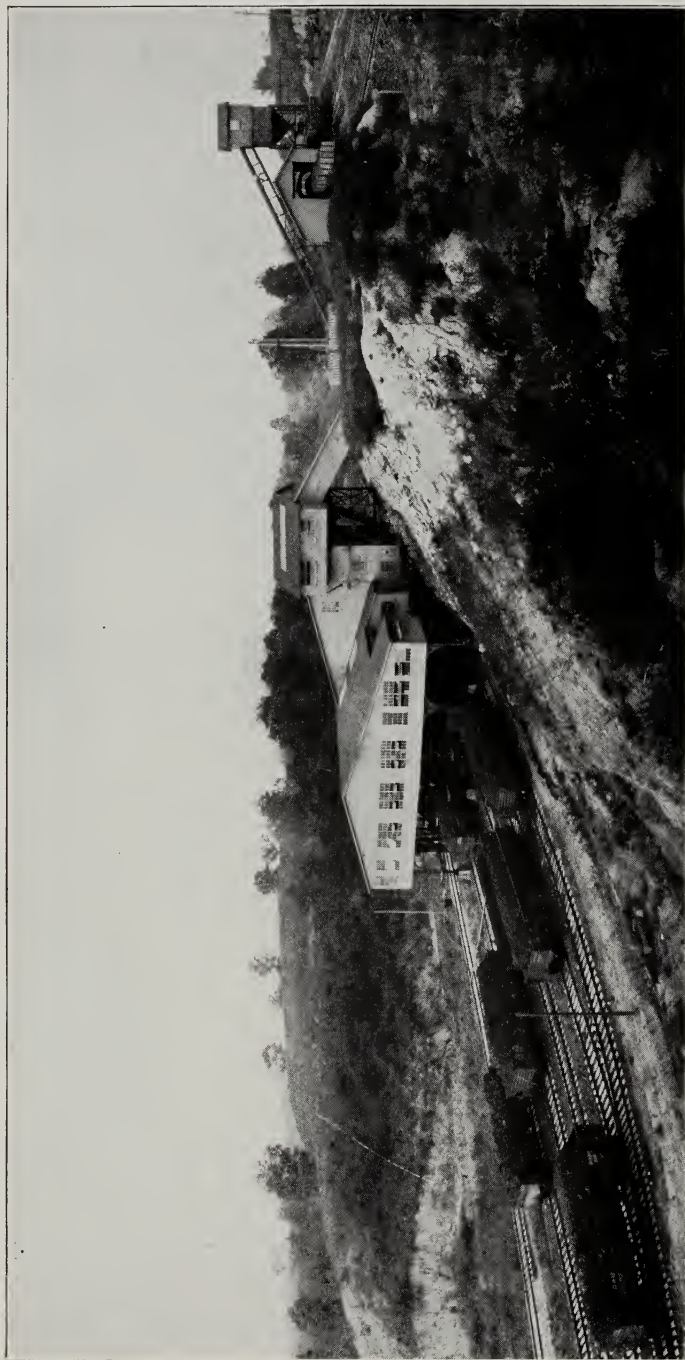


FIG. 29. Tipple at coal stripping mine in Fulton County, Illinois.

The apparent simplicity of the coal stripping operation is an incentive that often governs those who develop such property. The cost of the plant ready to produce coal is less than that of a shaft mine. The stripping method involves more mechanization and less labor than the shaft method. Figure 28 illustrates the remarkable development of the electric shovel brought about by the stripping method. Furthermore, under favorable conditions, the cost of producing a ton of coal may be less than in shaft mining. On the other hand the life of the stripping mine is much shorter than that of a shaft mine, for the area stripped is necessarily limited by the amount of cover. Because the stripping plant has a shorter life this method may in the end prove the more expensive. Experienced supervision, not always to be had, is imperative in order to meet the inevitable hazards from wet spells and consequent slides of spoil banks back into the workings. The re-handling of this material is apt to prove expensive. Drainage of the pit is always a somewhat serious problem and so is the recovery of the coal without including dirt that would reduce its quality.

In order to meet the competition of coal from shaft mining, modern tipples, like that shown in figure 29, must be constructed and the coal adequately prepared.

As underground mining in localities near the outcrop approached territory in which the cover over the coal was too thin to provide a suitable roof, mining ceased, and from the standpoint of underground mining such coal was abandoned and appeared as so much coal lost. In such places strip mining gives a more complete recovery of the coal.

In stripping coal the ground for a time is ruined (fig. 27). The damage to the land may be of little consequence in locations where the surface has no value for agricultural purposes, as for example, in Vermilion County, on branches of Vermilion River. In other localities, however, where land is agriculturally valuable, stripping may not be a conservative measure. Once the coal is removed the land is of no further value, for at least a considerable length of time, and then only after expensive leveling and perhaps soil treatment.

CHAPTER VI—PREPARED COAL

INTRODUCTION

Although operators attempt to produce a greater proportion of large-sized and a smaller proportion of fine coal, at best the coal as hoisted consists of a great variety of sizes and a more or less definite quantity of each size. There are now nine standard sizes produced as shown in Table 11.

TABLE 11.—*Standard sizes of coal*

<i>Item</i>	<i>Trade name</i>	<i>Dimensions in inches</i>
1	Lump	6 and over
2	Furnace	6 by 3
3	Small Egg	3 by 2
4	Stove or No. 2 Nut	2 by 1¼
5	Chestnut or No. 3 Nut	1¼ by ¾
6	Pea or No. 4 Nut	¾ by ¾
7	Carbon or No. 5 Nut	¾ and less
8	2-inch Screenings	2 and less
9	1¼-inch Screenings	1¼ and less

Lump and No. 2 nut coal are shown in figures 30a and 30b respectively.

PREPARATION OF COAL AT THE MINE

DEVELOPMENT OF PRESENT METHODS OF PREPARATION

During the early period of Illinois production there was practically no market for fine coal such as screenings, hence as much large-sized coal was produced as possible. In mining, the seam was undercut by hand-pick to facilitate its removal with minimum breakage, but the undercutting produced a quantity of small sizes and there was some breakage of the large coal. Fine coal from these two sources, without value, was hoisted with the large size and was removed by screening. The screens were simple, consisting of iron bars set at a rather sharp angle a little distance apart, and the coal moved over the screen by gravity to the railway car. The salable product was lump coal that passed over the 1½ to 2-inch screen, depending on the space between the bars, and the miner was paid only for the amount of screened coal he produced.

The introduction of mechanical stokers for power boilers furnished a market for small coal, for these furnaces could not use the larger size. At first screenings could be obtained in some places merely by paying the freight and this was considered a cheap way of solving the problem of disposal at the



FIG. 30a. Lump coal, including that which is retained on a 6-inch screen.



FIG. 30b. No. 2 nut coal—that which passes a 2-inch screen and is retained on a $1\frac{1}{4}$ -inch screen.

mine. Later a few cents per ton covered the mine price. As the use of stoker furnaces increased, the market for screenings increased, as well as the price. The result was a change in payment from a screened-coal basis to a mine-run basis and, as payment was the same for small and large coal, the incentive to produce large coal ceased to influence the method of mining.

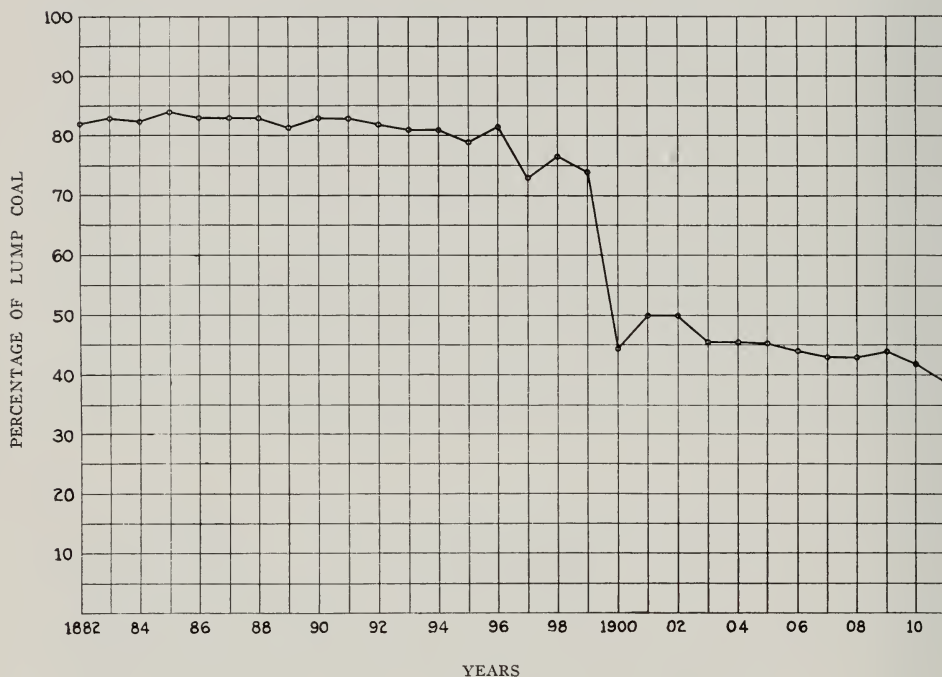


FIG. 31. Percentage of total State production reported as lump coal from 1882 to 1910. The drop in the curve after 1899 reflects the change from a screened-coal to a mine-run basis of payment. (From data in reports of the Department of Mines and Minerals.)

Figure 31, showing the percentage of lump coal produced, is plotted from reports of the Illinois Department of Mines and Minerals and covers this period of transition. Prior to the year 1896 the coal reported as "lump" was coal over the screen, a mixture of sizes. At the present time, the term "lump" refers to all sizes of coal passing over a screen having round holes 6 inches in diameter. During the period of the screened-coal basis of payment the miner used a minimum amount of powder in blasting out the coal but with the change to the mine-run basis of payment the use of explosives increased great-

ly, as shown in figure 32. This diagram explains in part the condition illustrated in figure 31.

This change in mining led to over-production of fine coal. There was a rapid growth in the number and size of stoker-fired furnaces, but not enough to absorb the screening production. Although the demand became sufficient to command a gradually increasing price it has never been high enough, under normal conditions, to equal their cost. Screenings, therefore, sell for less than the cost of production, and this of course has resulted in the maintenance

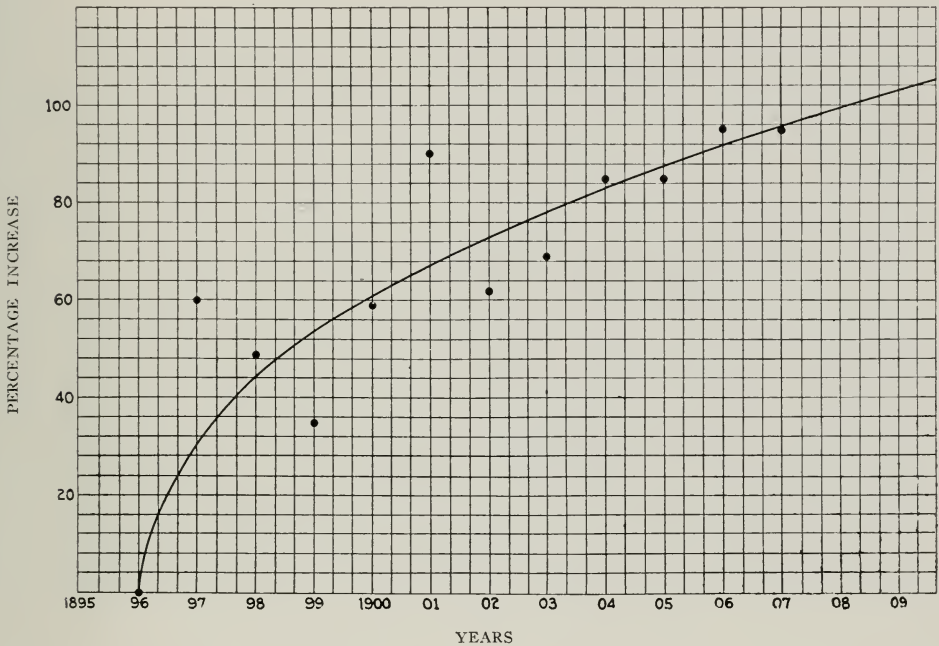


FIG. 32. Average curve showing increase in the use of powder per ton of coal to blast out coal after the change from a screened-coal to a mine-run basis of payment. (From data in reports of the Department of Mines and Minerals.)

of a price for the larger sizes high enough to cover the loss occasioned in marketing the screenings. The use of stoker-fired furnaces has grown so rapidly that if there had not been increased efficiency in the use of coal the demand for screenings at the present time would probably be greater than the supply, with the result that the price for this coal would be equal to that of mine run. In 1900 the amount of coal required to generate a kilowatt hour, in the best electric plant using Illinois coal, was 5.2 pounds. At the present time it is about 1.5 pounds. Increased economy in general service has been proportional.

In addition to the demand for stoker fuel a growing demand for mine run coal came to absorb a considerable portion of the small-sized coal. After 1899, when due to the mine-run basis of payment a portion of the cost of producing screenings had to be assessed against the screened coal, many coal users began to buy mine run coal because of the lower price. The demand for mine run, of course, decreased the production of screenings. The market for mine run coal has, however, in turn declined in a marked degree in more recent years as the user has learned the advantage of prepared coal over mine run. In response to the demand for the prepared coal operators have enlarged their screening plants to produce a variety of sizes.



FIG. 33. Shaker screens used in making prepared sizes of coal.

PREPARATION EQUIPMENT

The making of these standard sizes requires elaborate screening equipment and tipple plants. The coal is discharged from the weigh hopper to the screen having the smallest openings, then to successive screens having increasingly larger openings. The first screen, having $1\frac{1}{4}$ -inch holes, makes $1\frac{1}{4}$ -inch screenings, which are either discharged directly to the railroad car and shipped as such, or conveyed to the re-screener to be separated into the small prepared sizes. The remaining coal passes to the 2-inch screen, which makes coal 2 by $1\frac{1}{4}$ inches; then to the 3-inch screen, which produces coal 3 by 2 inches, from which it passes to the 6-inch screen (fig. 33), which makes coal 6 by 3 inches. The coal that passes over this screen is called 6-inch lump and

is in size 6 inches or larger. The photograph shows these screens one below the other, set at a slope to facilitate the movement of the coal, which is accelerated by a vibratory motion. These are usually referred to as "shaker screens". Coal 3 by 2 inches, 6 by 3 inches, and lump, pass from the screen to the picking tables (fig. 34), at which men are employed to pick out of the moving coal such foreign matter as the miner failed to remove when he loaded the coal into the pit cars in the mine.

The coal 2 by $1\frac{1}{4}$ inches, or 2 by $1\frac{1}{2}$ inches, depending on the size adopted in preparation, passes from the screen to the loading conveyor, but



FIG. 34. Picking tables at which men are stationed to pick out foreign matter from the moving coal. This stage is intermediate between grading and loading on railway cars. (This applies only to coal over two inches in diameter.)

is not hand picked. Screenings go direct to the railway car, for it is not necessary or feasible to pick these small sizes. If certain sizes are to be eliminated such screen plates are blanketed over. In this connection one of the recent developments in tipple design is a cross conveyor that allows different sizes to be put back together again.

Buyers of a definite size of coal demand that it reach them with a minimum amount of breakage. This requires careful handling and additional equipment in the tipple, particularly in the loading of sizes over two inches. When the coal is broken down in the mine by the explosives some of the pieces become shattered or are cracked so that they fall apart in passing over the screen. Such broken coal passes through the screen to the next smaller size, but to make sure that all of it is removed the 6-, 3-, and 2-inch main

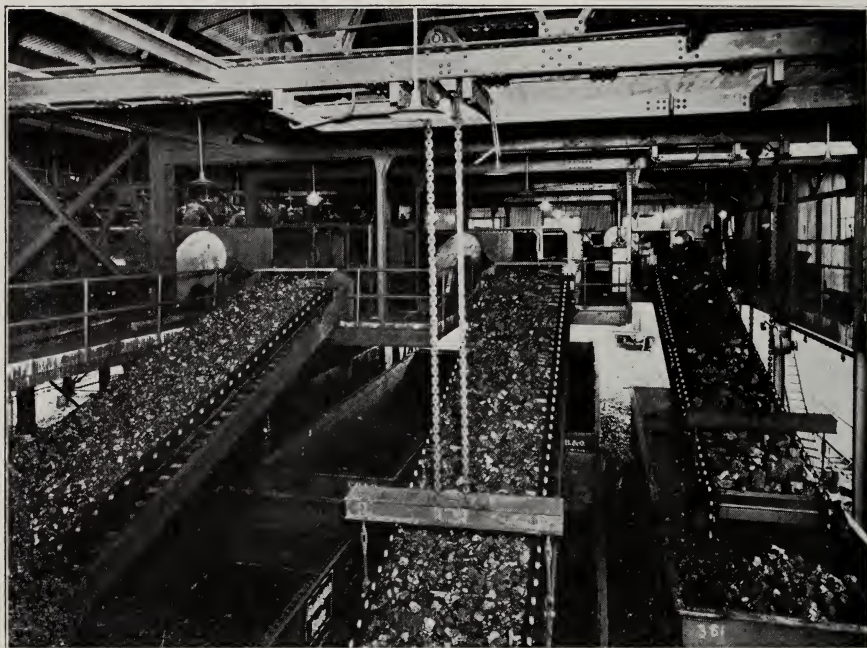


FIG. 35. Adjustable loading conveyors that carry the coal from the picking tables to the railway cars.

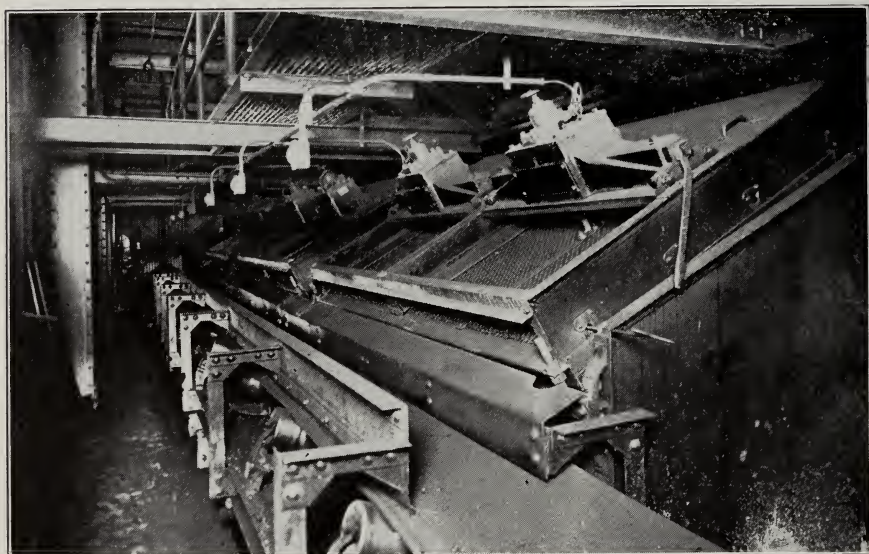


FIG. 36. A battery of screens for separation of small coal into prepared sizes. These screens are given a rapid vibratory motion, and they discharge directly to a conveyor belt. The coal that goes through the screens is conducted to other screens where a still smaller size is made.

screens are provided with supplemental screens and in effect these sizes are double-screened. After the coal leaves the screens and the picking table it passes to a moving conveyor (fig. 35) for loading in railway cars. The end of this conveyor, which reaches the car, is so arranged that it may be readily raised or lowered and the coal is placed without falling as the car is gradually moved while being filled.

PREPARATION OF SMALL SIZES

Small coal, or screenings, is following the same market trend as mine run, and such coal is separated by a battery of screens (fig. 36) into small prepared sizes as shown by items 4, 5, and 6 of Table 11, just as coal over two inches is separated into large sizes.

The preparation of these small sizes began in Williamson County. The first mine plants and methods were crude, as compared with present practise, but they were quite advanced for that time. Williamson County operators early adopted the coal washing process for the purpose of lowering the ash content by reducing the foreign matter in screenings. It so happened that in the washing process adopted the coal was first separated into sizes as items 4, 5, 6, and 7 (Table 11), and each size was washed separately. Having separated the coal the mine operator did not entail the expense of reassembling the sizes but sold them separately, giving each a distinctive trade name, as Nos. 2, 3, 4, and 5. In that day, 3 by 2 inch coal was called No. 1 nut, as the leader of the numerical order, but was not washed. The washed sizes were then known as Carterville washed coal, from the original shipping point, and became very popular, not because of their uniformity but on account of being washed.

In 1904, production began in Franklin County from the same No. 6 coal seam mined in Williamson County, and soon the same preparation was made by separating the screenings but without washing. It became apparent that the value was due to the sizing rather than the washing of the coal and leadership in the making of these sizes passed from Williamson to Franklin County.

The localities now leading in production of the small prepared sizes are the counties of Franklin, Saline, Williamson and Madison. Coal washing has declined, but the demand for the unwashed small preparation is growing rapidly. Experience has shown that its value lies in uniformity of size and that it is more satisfactory to keep the coal clean by careful mining than to wash out the dirt.

As a result of the preparation of these small sizes, carbon, $\frac{3}{8}$ inch and less in size, has little value now as a stoker or hand-fired furnace fuel. It has, however, a special market with certain industries that burn coal in the form of powder for it requires but a minimum amount of grinding. This market

is growing because of the increasing use of pulverized coal as a steam-making fuel.

Formerly coal-washing plants were common at mine shafts, especially at those working the No. 6 coal seam. Washing was carried on most extensively in Williamson, Madison, and Macoupin counties; in the first county the practice has declined to a marked extent, but in the last two it is still continued on much its former scale (fig. 37).

In the Third Vein (LaSalle) District, where the longwall method of mining is employed, the seam is undercut by hand-pick in the fireclay below the



FIG. 37. A coal mine tippie and washery at Staunton, Illinois. The washery is located to the left of the tippie.

coal. This is done to remove the support from below the coal in order that the pressure from above will break it down. As a result, a considerable quantity of fireclay becomes mixed with the fine coal, and this fine coal must be washed to make it salable. It is sold generally in the form of $1\frac{1}{4}$ -inch screenings. This method was also practised in the Wilmington District though mining has been discontinued in that area. The production of fine coal, however, is not large, because the amount of breakage in this system of mining is small, and only a limited proportion of the output requires treatment. Some coal was washed in the Grape Creek District to remove dirt due to unfavorable roof conditions. Coal washing has been confined entirely to the product from seams Nos. 2, 6, and 7.

Prior to the time the small prepared sizes were made by the dry process these washed sizes commanded a market because they were washed and not because of preparation, or sizing. When it was realized that the increased value was due to sizing instead of washing the washed product could not compete with the dry prepared coal, except in districts employing the longwall method of mining, because of the overhead expense, the cost of maintenance of the plant, and the loss of fine coal. One of the special difficulties met with in marketing washed coal is that in cold weather it freezes as it is loaded and makes unloading difficult and expensive.

MARKETING OF PREPARED COAL

It is apparent that with a demand for nine sizes the coal producer must seek the users of the different sizes. This involves a higher cost of selling, and the preparation of the sizes requires more expensive equipment than if all customers were satisfied with mine run.

Although for a time operators placed some emphasis in their sales departments on selling a combination of prepared sizes, it has worked out that users of coal generally prefer only one of these sizes. Only occasionally do the larger operators receive orders for mixed sizes, or mine run, other than for railroad fuel.

USE OF PREPARED COAL

SMALL-SIZE COAL AS STOKER FUEL

Although the market for small prepared sizes is growing, their value, especially for stoker fuel, is not well understood. The reason is in part historical. When mechanical stoker furnaces were first introduced the only fuel that could be used was screenings, available at a low price. At that time the advantage of a stoker-fired furnace over the hand-fired furnace as an economical and convenient investment was not sufficiently appreciated to justify the higher cost of installation. The difference in the price of coal used in the stoker-fired furnace as compared to that used in the hand-fired furnace was, however, readily apparent, and this stimulated the installation of stokers. The original low price no longer prevails and the small prepared sizes are taking the place of screenings as a more economical fuel.

At the present time for points in Iowa, Minnesota, and Wisconsin the freight rates for coal 2 inches and less in size are 17 to 36 cents per ton below the rates for larger coal. This rate system has become known as a "screenings rate" and for this reason users' attention has been centered on screenings. They have not always realized that these rates also apply to shipments of small prepared sizes of coal.

RESEARCH IN THE USE OF SMALL SIZES

One of the difficulties in understanding the superiority of small prepared sizes over screenings has been the fact that the B. t. u. of small prepared coal is only from 2 to 4 per cent greater than that of screenings. It is quite natural that, in the absence of more comprehensive data, the B. t. u. was formerly considered the chief basis for comparison. (See pp. 92, 97-98.)

However, the problem has been studied by various coal consumers in research experiments on steam production in chain-grate stokers¹ with results

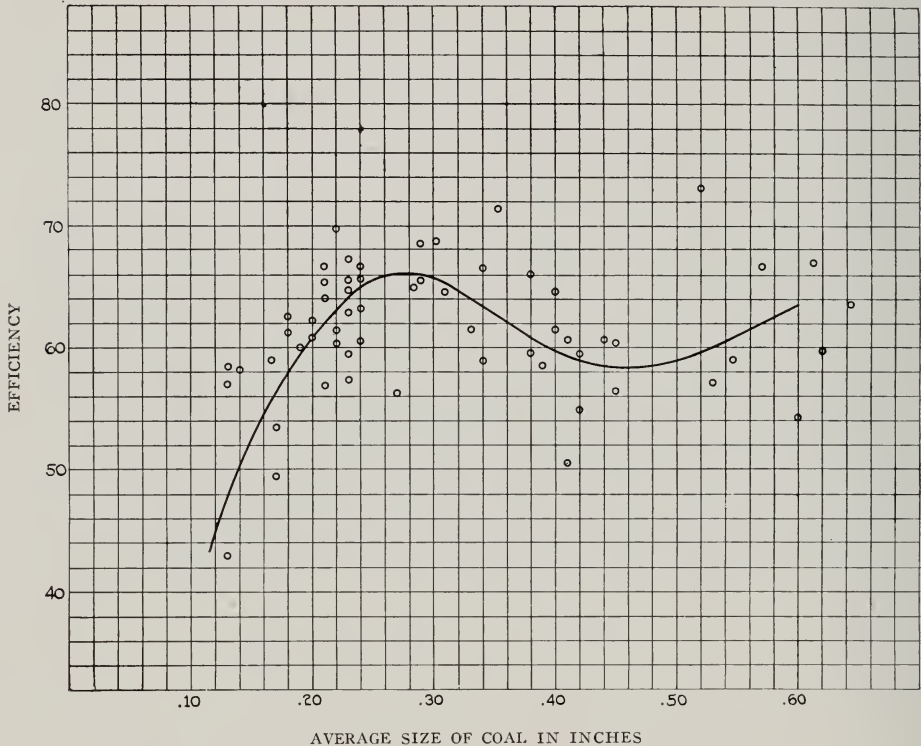


FIG. 38a. Curve showing the behavior of coal screenings in efficiency of steam production. (After Abbott, W. L., Some characteristics of coal as affecting performance with steam boilers: *Journal Western Society of Engineers*, vol. 11, 1906.)

that have prompted a growing demand for the small prepared coal. Figures 38a and 38b are based on some sixty tests of $1\frac{1}{4}$ -inch screenings, made under the same conditions. The screenings were fed to the chain-grate stoker hopper from an overhead bunker. As shown, horsepower and efficiency of combustion were influenced by the size of the coal.

¹ Abbott, W. L., Some characteristics of coal as affecting performance with steam boilers: *Jour. Western Soc. Engineers*, vol. 11, p. 534 ff., 1906.

The screenings used in these tests all analyzed about the same, the B. t. u. not varying more than 3 per cent. The differences in performance, on the basis of efficiency, ranged up to 70 per cent, and capacity differences ranged up to 400 per cent. Some of the highest B. t. u. coal gave poor results, and some of the lowest B. t. u. coal gave excellent results. These screenings were all from one locality, and the tests did not really consist of trial of different coals, but rather were continued tests of the same coal. Differences in performance were due principally to the degree of bunker separation.

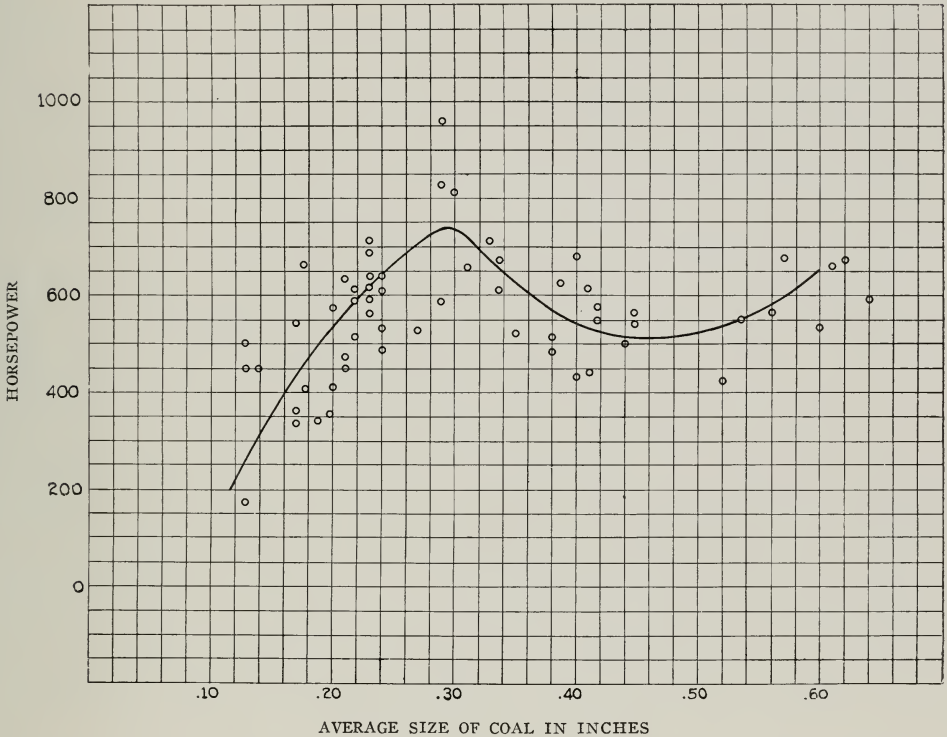


FIG. 38b. Curve showing the behavior of coal screenings in capacity in steam production. (After Abbott, W. L., Some characteristics of coal as affecting performance with steam boilers: *Journal Western Society of Engineers*, vol. 11, 1906.)

REASONS FOR THE RANGE IN PERFORMANCE OF SMALL SIZES

The diagrams show that when the coal used was of small diameter, or contained a large quantity of "duff" or of very small pieces, performance was poor; as larger coal was used the performance became better until the average diameter was 0.29 inch and this gave the best result. With slightly larger coal the performance dropped, to rise again as the coal became still larger.

The chief reason for the range in performance is the difference in the condition of the fuel bed. When fine coal predominates the fuel bed is too dense, and the result is that air does not penetrate properly, causing the coal to burn slowly and produce less heat. After the volatile matter had been driven off the coal tends to cake and become coke. The coke forms in masses which burn through in places and allow excess air to flow through the fuel bed.

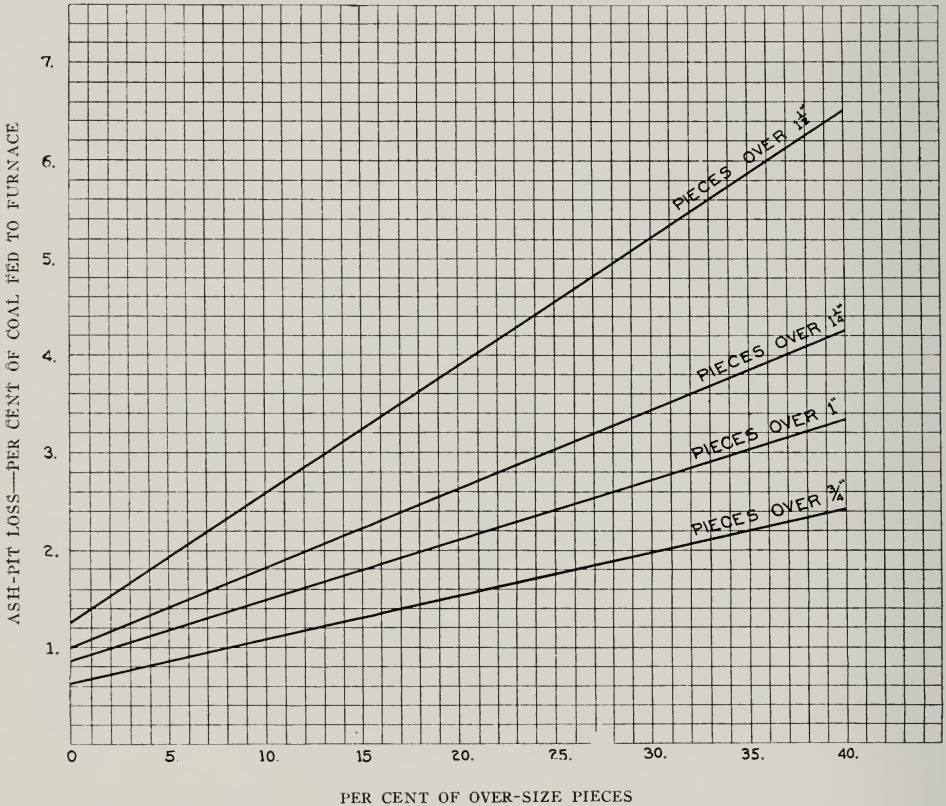


FIG. 39. Relation between over-size of coal in screenings and ash-pit loss of un-burned coal as determined by tests with chain-grate stoker. (After Duennes, F. C., Fuel preparation for chain-grate stokers: Power, vol. 62, No. 21, 1925.)

When the large size of coal predominates in the screenings the fuel bed is too porous and allows excess air to flow through. The air supply may be so excessive at the front of the grate as to prevent temperatures high enough to ignite the coal. This so reduces the capacity that steam pressure falls and the plant may not be able to carry the load.

If an ideal mixture of sizes could be obtained, the value of screenings as a fuel would be relatively high, but uniformity of mixture with proper proportion of suitable sizes cannot be obtained. Even if uniformity of mixture could be assured at the mine, it would be destroyed by separation in bunkers and bins.

An illustration of how separation occurs may be taken from a plant at which screenings were unloaded through windows onto the floor in front of

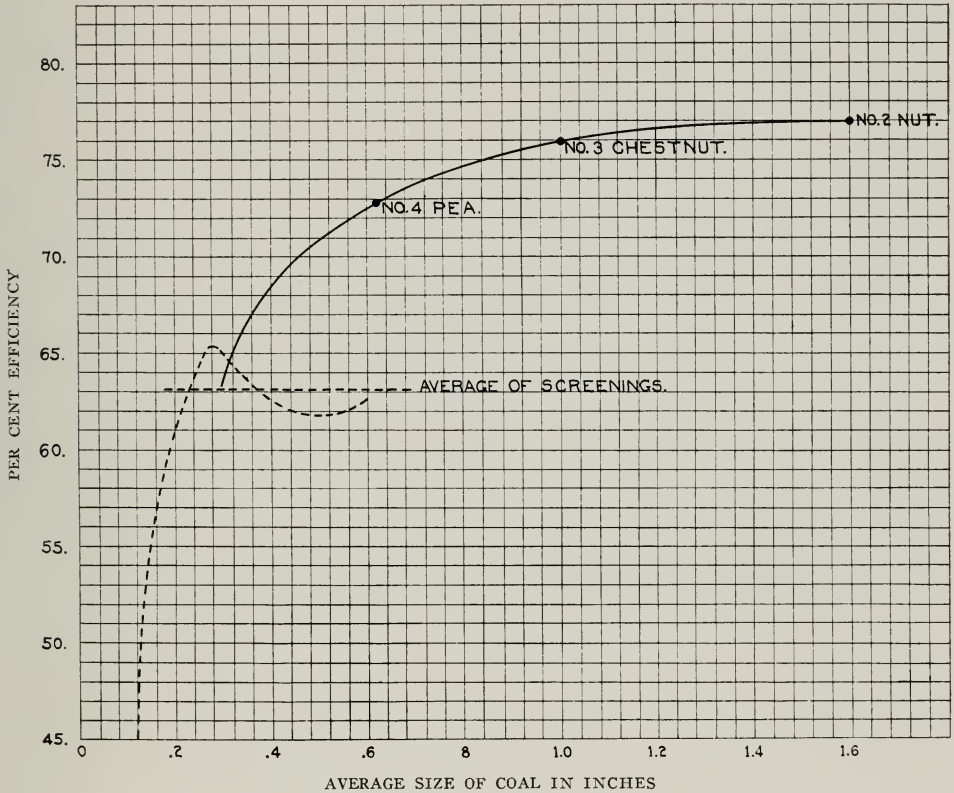


FIG. 40a. Curves showing comparison of the behavior of screenings and small prepared sizes of coal in efficiency of combustion. The dotted line is transferred from figure 38a, the full line is added by the author from his studies.

the boiler. The large pieces rolled down in front and were the first fed to the hopper. Later as the pile was reduced the small sizes were used. There was serious trouble and it was always difficult to hold steam pressure. The head fireman in explaining his trouble said, "These large pieces are so hard they will not burn, and the fine stuff lies like sand." He obtained best results of course when there was a good mixture of sizes.

Another factor in the performance of screenings, especially with chain-grate stokers, is the loss of fuel with the ashes as they go over the end of the grate. The larger pieces of coal do not burn as fast as the smaller, with the

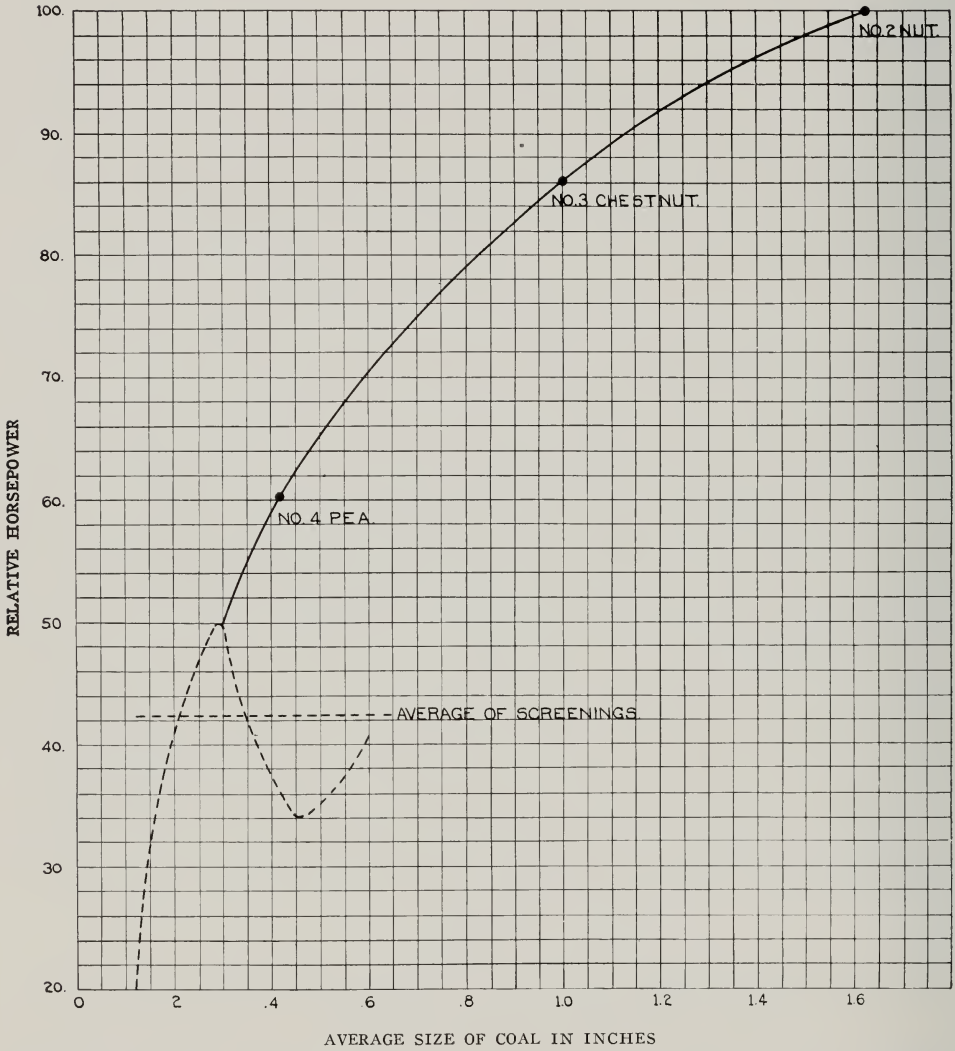


FIG. 40b. Curves showing comparison of the behavior of screenings and small prepared sizes of coal and capacity of steam production. The dotted line is transferred from figure 38b, the full line is added by the author from his studies.

result that they arrive at the end of the grate as pieces of coke and are discharged with the ashes. Figure 39² gives the results of a recent test

² Duennes, F. C., Fuel preparation for chain-grate stokers: Power, vol. 62, No. 21, p. 798, 1925.

made to determine this loss as influenced by the quantity of over-size pieces of coal. For example, note screenings containing 40 per cent of sizes over $1\frac{1}{2}$ inches. Following up from 40 at the bottom of the diagram to the curve "pieces over $1\frac{1}{2}$ inches", then to the right, it will be seen that there is a fuel loss of 6.5 per cent. This diagram shows that as over-size of coal decreases so does the ash-pit loss. Chain grates could be so operated, of course, that these larger pieces would be completely burned, but to do so would require running short fires, and the excess air entering the furnace through the back end of the grate would cause greater loss from this source than the gain due to completely burning the coal. If the pieces of coal were the same size they would all burn at a uniform rate, and so arrive at the end of the grate uniformly consumed.

COMPARATIVE PERFORMANCE OF SCREENINGS AND SMALL PREPARED SIZES

Figures 40a and 40b show the comparative performances of screenings and small prepared sizes of coal with reference to efficiency of combustion and capacity secured in steam production.

From the standpoint of fuel economy the small prepared sizes of coal are not subject to the variable characteristics of screenings. They afford a fuel bed sufficiently porous to insure proper air penetration, and when the fire-thickness is suited to the size of coal excess air is avoided. The fuel bed is in condition to take sufficient air for good combustion, but not so much air as to cause loss of heat. The small sizes not only burn uniformly and freely, but with the same strength of draft they burn much faster than do screenings. It is for these reasons that the uniform preparation gives a more satisfactory performance than screenings.

CHAPTER VII—ANALYSES OF COAL

ORIGIN AND PHYSICAL CHARACTER OF COAL

From peat beds of enormous extent and great thickness which existed in the Illinois coal basin during Pennsylvanian times have come our present coal beds. These peat beds were made up of partly decomposed portions of trees and undergrowth which grew in luxuriant profusion in the forest swamps of the period. The change from peat to coal is believed to be due to pressure of overriding sediments beneath which the peat became buried, to other earth pressures, which in parts of the coal basin produced folding and faulting of the rocks, and to a less degree to heat from the interior of the earth. As these influences made themselves felt the peat was gradually changed to lignite, then to sub-bituminous coal, and finally into bituminous coal within which rank it is now classified.

The physical components of bituminous coal are readily discernible. Within any piece of Illinois coal one can generally recognize three differently appearing layers or bands. These are the bright or glance coal, the dull coal, and the mineral charcoal, the last having the characteristic appearance which suggests its name. The glance coal is composed of woody material which was incorporated into the peat swamp, and the dull coal is composed of various sorts of plant materials, crushed wood fragments, pollen, resin, seed cases and other more resistant parts of plants. Some doubt exists as to the origin of the mineral charcoal. It is thought by some investigators actually to represent charcoal resulting from forest fires, by others it is regarded as the effect of oxidation of the surface of the peat during periods of exposure. It is possible that more than one cause was operative in its formation.

CHEMICAL CHARACTER OF COAL

COAL ANALYSES

Curiously enough, although chemical analysis of coal is a matter of great interest, it has not until recently occupied much of the attention of chemists, and even yet very little is known about the chemical nature of the substances occurring in coal.

PROXIMATE ANALYSES

What then are the coal analyses which are so commonly presented as evidence of the character of coal? Those known as proximate analyses

have been worked out by the industrial chemist and industrial user of coal to reveal the behavior of the coal in combustion. The commercial user is interested in the proportion of non-combustible and combustible ingredients in coal. The most important non-combustible substances are moisture and ash, and the relative proportion of each is of interest. The combustible portion consists of volatile matter, which may become smoke producing, and fixed carbon which is not smoke producing. There is also interest in regard to the actual heating value of the coal. In English speaking countries the calorific value is generally given in terms of British thermal units, commonly abbreviated to B. t. u.—one B. t. u. being the heat required to raise the temperature of one pound of water one degree Fahrenheit.

A proximate analysis of a sample of coal, therefore, states the amount of ash, moisture, volatile matter, fixed carbon, and B. t. u. The amount of sulphur present is also commonly included.

METHODS USED IN OBTAINING THE CHEMICAL DATA ON ILLINOIS COAL

Many proximate analyses have been made of Illinois coal from samples carefully collected according to standard practise from the face of the coal seam. In no case were the samples taken from cars. A total of 858 samples were collected from 242 mines, analyzed, and the results assembled in the forms shown in Tables 13 and 14. The analytical work was done in part by the United States Bureau of Mines and in part by the Department of Industrial Chemistry of the University of Illinois.

MOISTURE IN COAL

By referring to Tables 13 and 14, pages 99-107, information may be obtained as to the various substances in the coal, the former table giving the data by counties and the latter by trade districts. The moisture content shown in these tables is that moisture which is released by the coal when heated under specified conditions for one hour at 221° Fahrenheit (105° Centigrade). It is well to bear in mind that the data given are for samples obtained from the face of the coal seam in the mine, and that the moisture content of coal in the seam is fairly uniform for a considerable area, and for as much as a county. Changes in moisture content during shipment cause much confusion, trouble and controversy, because it is not always understood that coal is purchased as loaded and weighed at the mine. Where domestic users are buying coal after it has been for some time on cars or in dealers' yards, purchases in hot, dry weather have the advantage of being better from the standpoint of lower moisture content and higher B. t. u. per ton than purchases in cold, wet weather, these advantages being in addition to the usual lower summer price.

ASH

Ash in coal as loaded for shipment is a variable quantity. It is the one ingredient of coal represented in the proximate analysis over which the mining companies exercise control. The possible ash substance which appears in the coal shipment is derived from three sources: (1) from the coal substance itself; (2) from impurities in the coal seam; and (3) as dirt and rock from roof or floor which may become mixed with the coal in process of mining.

Ash of the first variety is the inherent ash which represents the ash in the woody substances from which the coal is composed. Over the quantity of this ash the producer has no control. The quantity of the second and third

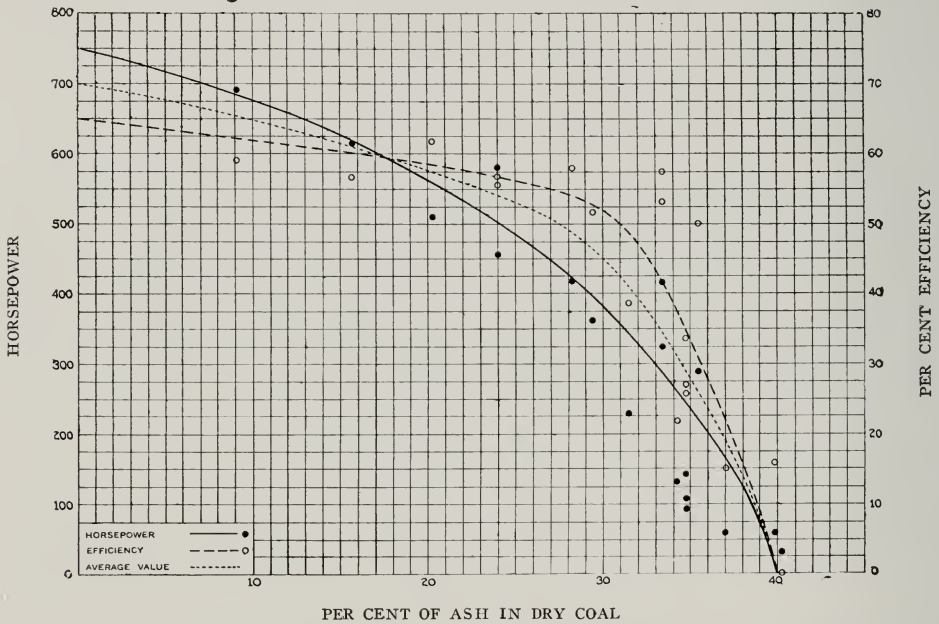


FIG. 41. Relation between the per cent of ash in dry coal and the efficiency and horsepower developed during tests. (After Abbott, W. L., Some characteristics of coal as affecting performance with steam boilers: Journal Western Society of Engineers, vol. 11, 1906.)

varieties of ash are under his control, for by care in mining and preparation the amount of this ash shipped in the coal may be kept at a minimum. The importance of careful preparation and the resulting reduction in the ash content of the prepared coal rests partly on the fact that carefully prepared coal has higher heat value than poorly prepared coal, because of the greater proportion of heat producing material in the shipment.

The analyses which show the composition of coal on a dry basis (Table No. 13, pps. 99-104, condition 2, see any county) show the ash content on a

better comparative basis than do analyses in which moisture is included (condition 1 of same table). This is because in its combustion coal loses moisture by evaporation, leaving coal and ash, and the proportion of ash in the dry coal determines the amount of heat to be expected in combustion. For example moisture and ash are each 10 per cent, this moisture is expelled by the heat of the fire; therefore the ash that interferes with combustion instead of 10 per cent is 11 per cent of the coal burned. If moisture is 15 per cent and ash is still 10 per cent, then the ash that interferes with combustion is 12 per cent. The use of the dry coal analysis as a means of comparing the relative proportions of ash and coal substances is the only instance of its legitimate and useful application. Figure 41 shows the relation between the

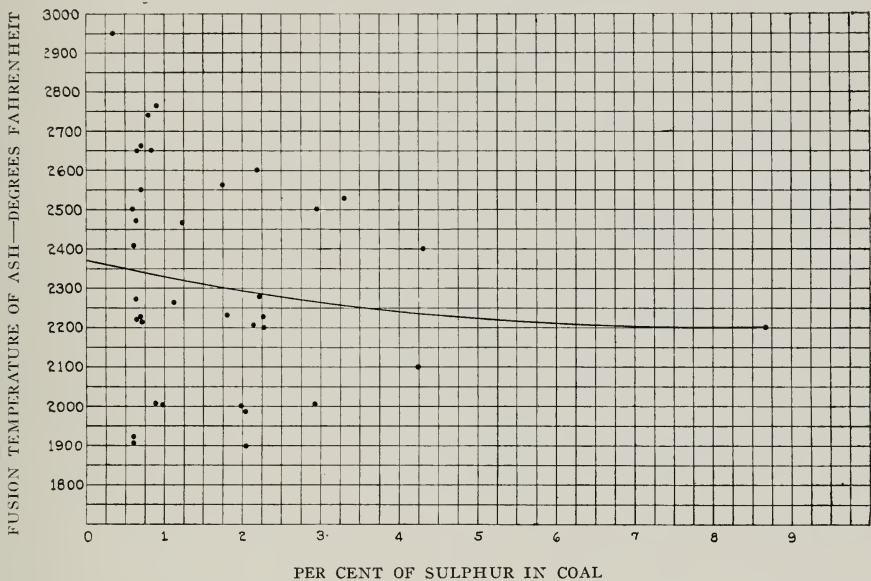


FIG. 42. Relation between the sulphur content of coal and the fusion temperature of the ash. (After Langtry, W. D., *The fusion temperature of coal: Power*, vol. 67, p. 192, 1928.)

per cent of ash in dry coal and the efficiency and horsepower obtained in combustion.

The melting temperature of ash varies for different coals, but on the whole the melting temperature of ash of Illinois coal occupies a relatively low position with respect to that of coal of other fields.

To the commercial consumer sulphur has long been thought of importance in its effect upon the melting point of ash, it being thought that the high-sulphur coals are commonly those the ash of which has a tendency to melt and

clinker in the fire. However, high-sulphur coal may or may not be accompanied by ash with a low fusion point, and not all easily fusible ash is found in high-sulphur coal. In tests of coal having a sulphur content of less than one per cent Langtry¹ found a range in the fusion temperature of from 1900° to above 2750° Fahrenheit, while ash from coal having 4.3 per cent sulphur had a fusion temperature of 2400°. These tests, therefore, show that the amount of sulphur can not be taken as an indication of clinkering tendency. (See fig. 42.)

VOLATILE MATTER AND FIXED CARBON

The volatile matter shown in the proximate analyses (Tables 13 and 14) consists of those gases which are driven off when the coal is heated to a temperature of approximately 1742° Fahrenheit (950° Centigrade) less the moisture. The residue, less the ash, is called fixed carbon. The true proportions of volatile matter and fixed carbon are shown only in a moisture- and ash-free analysis (condition 3 of Table 13). If condition 1 of Table 13 were alone considered, that is moist commercial coal as loaded, weighed and billed at the mine, two lots of coal having apparently the same relative amount of volatile matter and fixed carbon may have total amounts that are different due to difference in moisture and ash content.

So far as heat value is concerned volatile matter may have as high or a higher heat value than the fixed carbon, and in large industrial furnaces one should be as efficiently burned as another. Small domestic and some other furnaces do not utilize the volatile material so completely and as a result smoke is produced.

SULPHUR

Sulphur occurs in coal as organic sulphur which was originally part of the plant material, and also in mineral form of secondary origin. In mineral form it is present chiefly as iron pyrites in nodules, bands, and as thin vertical seams in the fine joints of the coal. Some sulphur is also present in the mineral gypsum which occupies thin vertical seams in the coal. This mineral and calcite form the thin white flaky substance commonly seen on a coal face when freshly broken. Sulphur, particularly from iron pyrites, is responsible for the sharp pungent disagreeable gas that occasionally escapes from a domestic heating plant, especially when hot clinkers are pulled from the fire.

Sulphur is a factor in gas manufacture, as it must be removed from the gas by purification before delivery to the consumer through the distributing system. This has led to the use of low-sulphur coal, and as eastern gas plants

¹ Langtry, W. D., *The fusion temperature of coal ash*: Power, p. 192, vol. 67, 1928.

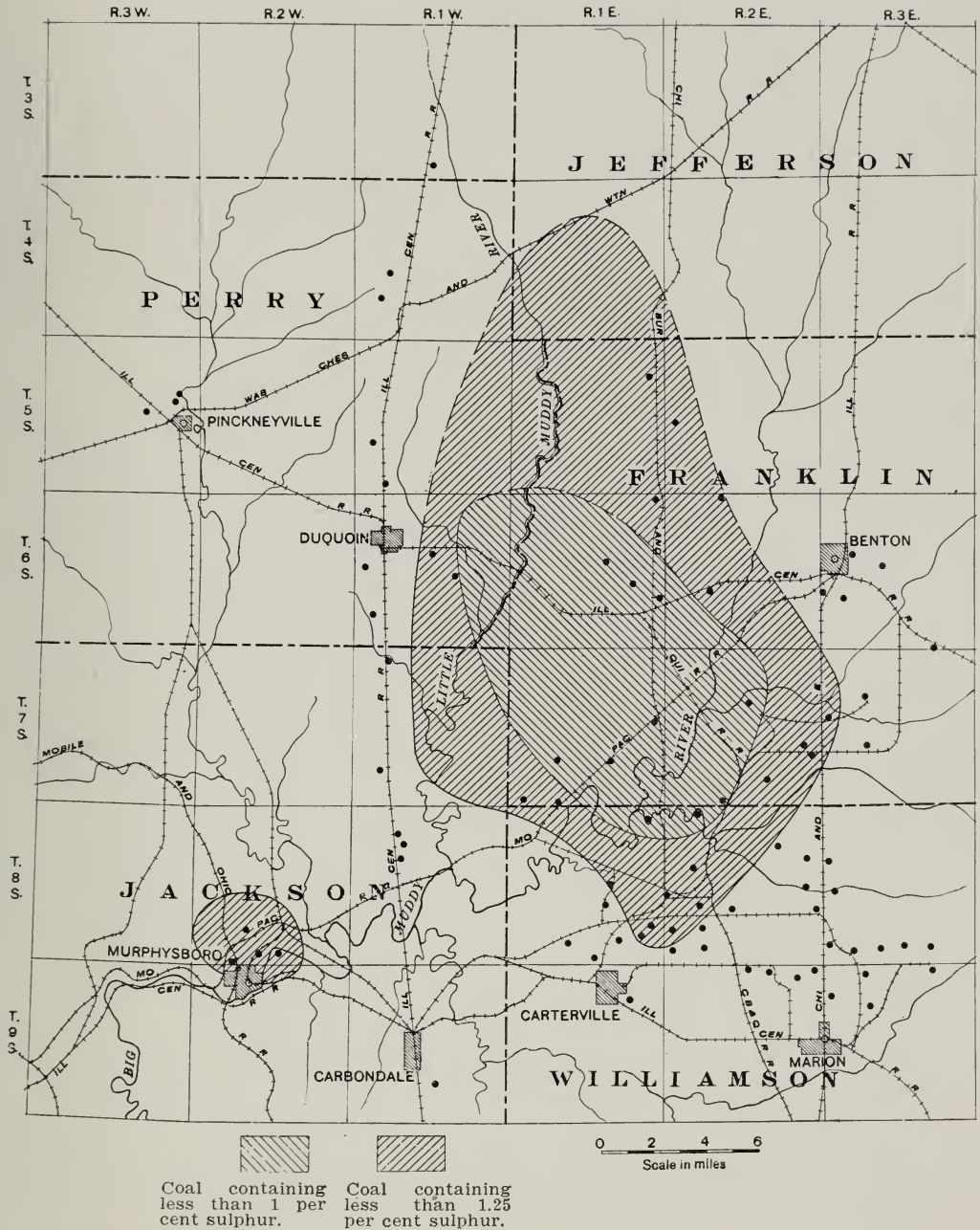


FIG. 43. Map showing location of low-sulphur coal in the Franklin-Williamson and Big Muddy districts. The Big Muddy District in Jackson County has been worked out. (Cady, G. H., Low Sulphur Coal in Illinois: Illinois Geological Survey Bulletin 38, fig. 58, p. 432, 1922.)

could easily obtain such coal supplied from comparatively nearby sources, there developed a practise in gas-plant design based on the use of low-sulphur coal. Capacity of purifying equipment considered necessary for a gas plant was based on the use of such coal. These plant designs were adopted as gas manufacture moved westward, with the result that in many small city or town gas plants it is often necessary to use eastern coal; not that the best Illinois coal would not be more economical fuel, but because of limited purifying capacity.

The effect of sulphur on the fusion temperature of ash is discussed on pages 89-90. Sulphur as an article of commerce has many uses and its recovery as a salable by-product from gas manufacture is a recent development.

Although in general the amount of sulphur in Illinois coal is in excess of 1.5 per cent, there are two areas in southern Illinois, as shown in figure 43, wherein the amount of sulphur is less than 1.25 per cent. In part of the areas, as shown by the map, the coal contains less than 1 per cent sulphur. In the smaller area, that in Jackson County, the coal has been nearly exhausted. Coals from other regions, under careful preparation, may have a sulphur content of less than 1.5 per cent. The map, however, refers to data collected from face samples.

A small area of coal No. 5 northwest of Galatia in northwestern Saline County is probably underlain by coal having less than 1.0 per cent of sulphur. The location of the area is known only from drilling as no shafts are operated. Surrounding this area of low sulphur coal is a larger area in which the sulphur content is prevailingly less than 2.0 per cent, but the outline of this area is likewise very imperfectly known.

HEATING VALUE (B. t. u.)

Inasmuch as coal from different sources may vary in the amount of heat which it can produce, it is very important to adopt a standard measure of heat value. B. t. u. is an abbreviation of British thermal unit, and as here used (Tables 13, 14, 15, and 16) applies to the heat value of one pound of coal, one B. t. u. being the amount of heat required to raise the temperature of one pound of water one degree Fahrenheit.

Coal as bought, sold, and supplied to the furnace has a natural moisture content and the only B. t. u. value that should apply in the transaction is that of the moist commercial coal (condition 1 of Tables 13, 15 and 16). Unfortunately the use of the B. t. u. value on a dry basis has also become quite general. This use has led to confusion and has been the means by which buyers not familiar with coal analyses have often been misinformed as to coal values.

IMPORTANCE OF ACCURATE B. T. U. DETERMINATIONS

It is sometimes thought that two to four per cent variation in B. t. u. tests is of little importance, so it is well to realize the effect of such differences

as expressed in money. The effect of a four per cent difference on the value of the coal is as follows:

1. Assume coal \$2.50 at mine, with freight \$3.55 per ton—cost at destination will be \$6.05. Four per cent of this sum is 24.20 cents per ton; on 10,000 tons of coal it will amount to \$2,420.00.
2. Assume screenings \$1.75 at mine, with freight \$3.35—cost at destination will be \$5.30. Four per cent is 21.20 cents per ton; on 10,000 tons, it will amount to \$2,120.00.
3. On the \$1.95 freight rate, coal at \$2.50 at the mine will cost \$4.45 at destination. Four per cent is 17.80 cents per ton; on 10,000 tons, it will amount to \$1,780.00.
4. Screenings on \$1.95 freight rate, at \$1.75 at the mine, will cost \$3.70 at destination. Four per cent is 14.80 cents per ton; on 10,000 tons, it will amount to \$1,480.00.

A two per cent variation will affect the value of a coal one-half the above amounts. No large user of coal can afford to ignore differences even as small as two per cent of the B. t. u. value. It is important therefore that such determinations be made with the standard of accuracy of the best laboratories. According to the Report of Committee D-5 on Coal and Coke, American Society for Testing Materials, the permissible difference in calorific value of tests in one laboratory is 0.3 per cent and of different laboratories is 0.5 per cent on the same sample of coal.

DETERMINING FUEL VALUES

The B. t. u. content is only one of several factors to be considered in the purchase of coal. Another factor is the size of the pieces of coal. The effect of difference in size of coal upon its efficiency as a fuel is given attention in Chapter VI.

Another factor is the effect of moisture and ash content on the combustion of coal in the furnace. For example, in the case of two coals of the same heat value, the one containing the most moisture has less available heat because of the heat consumed in evaporating the excess moisture. Likewise, coal with excessive ash gives less heat because of the greater interference with combustion. Therefore, in comparing one coal with another, the commercial B. t. u. may be subject to correction to compensate for excess moisture and ash.³

In steam boiler practise about 1256 B. t. u. are required in heating one pound of moisture to 212 degrees, evaporating it, and superheating the resulting steam to chimney temperature. Thus the heat required to remove the excess moisture which one coal contains compared with another is 1256 times the excess moisture for each 100 pounds of coal.

³ Bement, A., *Effective B. t. u. and cost determined value of coal*: Power, p. 448, September 18, 1923.

At the St. Louis Exposition tests of coal were conducted by the Technologic Branch of the United States Geological Survey (later Bureau of Mines) by burning coal under a boiler on a hand-fired grate. These tests showed that for each one per cent additional dry ash, the effective heat value of the coal as burned in the furnace was reduced by one and one-half per cent.

Tests with a chain-grate stoker,⁴ as shown in figure 41, page 88, gave, through the usual range of dry ash found in commercial coal, a reduction in value of the fuel of one per cent for each one per cent additional ash.

Table No. 12 shows the application of these corrections, using for ash the one per cent correction.

TABLE 12.—Comparison of effective fuel value of two coals

	COALS	
	A	B
1. Moisture	8.90	11.97
2 Excess moisture		3.07
3. Ash in dry coal.....	9.46	11.97
4. Excess ash in dry coal.....		2.51
5. B.t.u. by laboratory test.....	11936	10880
6. B.t.u. loss due to excess moisture (Item 2, 1256 times .0307).....		38
7. B.t.u. loss due to excess ash (Item 4, 10880 times .0251)		273
8. B.t.u. loss (sum of Items 6 and 7).....		311
9. B.t.u. effective (Item 5 less Item 8).....	11936	10569
10. Relative value of A and B (10569 divided by 11936, Item 9)	1.00	0.88
11. Mine price assumed for coal A	\$2.50	
12. Mine price derived for coal B		\$2.27
Coal B at destination should not have a price greater than 88 per cent of coal A.		

ULTIMATE ANALYSES OF COAL

Along with the proximate analysis there has developed another form of analysis known as the ultimate analysis which expresses the constitution of the combustible portion of the coal in terms of oxygen, hydrogen, carbon, nitrogen and sulphur (Table No. 15). This analysis provides the chemist and user of coal with somewhat more detailed information in regard to the combustible portion of the coal than does the proximate analysis.

For instance the amount of oxygen in the ultimate analysis enables one to tell how much of the volatile matter shown in the proximate analysis is moisture and hence not heat producing. All of this oxygen is regarded as being in combination with hydrogen as water of composition, in the ratios by weight of 8 to 1. The remaining hydrogen is known as free or available hydrogen since it is available to the oxygen of the draft for combustion. This

⁴Abbott, W. L., Some characteristics of coal as affecting performance with steam boilers: Journal Western Society of Engineers, vol. 11, p. 534, 1906.

combustion of available hydrogen and oxygen supplied by the draft produces heat and water. Water so formed is called "water of combustion".

Knowing the ultimate composition of coal it is possible to estimate the amount of air necessary for its complete combustion, carbon, available hydrogen and sulphur being the substances the oxidation or burning of which requires air. It is evident that in calculating the amount of air necessary for the combustion of hydrogen, the amount of available hydrogen as shown in Table No. 16 is the value to be used rather than total hydrogen given in Table No. 15. The amount of oxygen necessary for this reaction is 8 times by weight the amount of available hydrogen.

COMBUSTIBLE AND NONCOMBUSTIBLE INGREDIENTS

The combustible ingredients are those which upon combining with the oxygen of the draft produce heat and are driven off as gases. These are carbon, sulphur and available hydrogen. Water of composition and nitrogen are driven off as gases by the heat of combustion but are not themselves combustible. The moisture of commercial coal is also driven off by heat of combustion and is noncombustible. Ash is the noncombustible portion which remains when the coal is completely oxidized or burned. Table No. 15 is so arranged as to show the combustible and noncombustible components of coal. The noncombustible elements are grouped together as the first four terms of the analysis; the three combustible elements follow; leaving for the last the calorific or B. t. u. value.

The relations may be expressed as follows:

$$\begin{array}{lcl}
 \begin{array}{l} \text{Carbon} \\ \text{Available Hydrogen} \\ \text{Sulphur} \end{array} & \left\{ \right. & \text{equals combustible} \\
 \\
 \text{Combustible plus} & \left\{ \begin{array}{l} \text{Water of composition} \\ \text{and} \\ \text{Nitrogen} \end{array} \right\} & \left\{ \begin{array}{l} \text{equals moisture- and} \\ \text{ash-free coal} \end{array} \right. \\
 \\
 \text{Moisture- and ash-free coal plus ash} & \text{equals dry coal} \\
 \text{Dry coal plus moisture} & \text{equals commercial coal}
 \end{array}$$

CONSTANT AND VARIABLE ELEMENTS IN COAL

Inspection of Tables 15 and 16 show that there are variations in all items. No two analyses are alike. Yet the amount of variation is quite different among the several items and it is known that variations in the coal and in mining conditions cause greater variations in the amount of certain ingredients than it does in others. In other words, there are certain elements which have a fairly characteristic value over considerable areas, provided the vari-

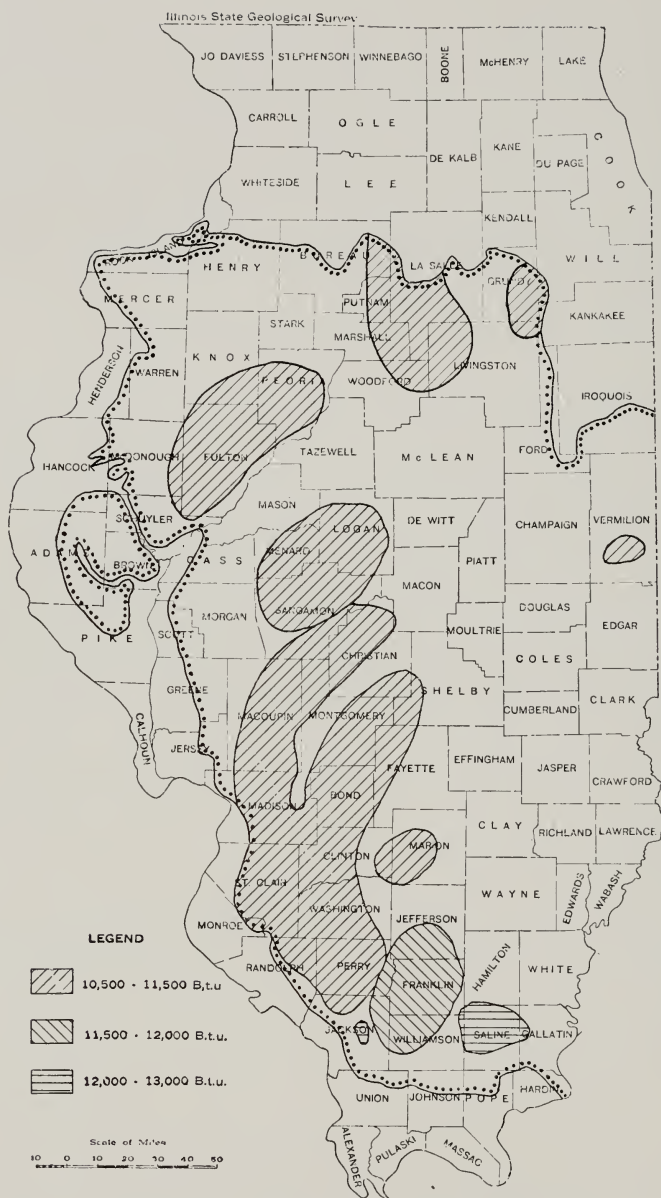


FIG. 44. Map of coal mining districts showing average B. t. u. values of the coal seams.

able elements are eliminated. The following table shows the constant and variable constituents in coal:

<i>Constant elements and combination</i>	<i>Variable elements and combination</i>
Carbon	
Hydrogen	Sulphur
Water of composition	Ash
Nitrogen	
Moisture	

As moisture commonly changes during coal shipment, either decreasing or increasing depending upon the weather, it is common to consider moisture a variable. The moisture content of face samples is, however, as constant for local regions as other items in the analysis.

The ultimate analyses include also a statement of calorific or heating value. As the values shown are the same as those given in the tables of proximate analyses and as these latter tables include additional county values the discussion of these values has been included in the discussion of the proximate analyses.

STANDARD CALORIFIC VALUES—ASH- AND MOISTURE-FREE COAL AND UNIT COAL

The B. t. u. value of coal is determined by the combustible elements in the volatile matter and fixed carbon, namely, carbon, hydrogen and sulphur. As the content of carbon and hydrogen remains about constant in a general region, the greatest source of irregularity is the sulphur, the amount of which varies considerably within the same seam. If the sulphur did not vary but was a constant as are hydrogen and carbon, it is apparent that B. t. u. value of coal would vary only in response to variations in the ash and moisture. The ash- and moisture-free B. t. u. value would therefore be a very exact value for each coal in local regions such as counties. All B. t. u. determinations of coal from the same bed in the same county calculated to an ash- and moisture-free basis should closely approximate one another. It is largely because of variations in the amount of sulphur that there are variations in the ash- and moisture-free B. t. u. values within local areas. However, it is believed that county B. t. u. values on an ash- and moisture-free basis for each seam probably come nearer to representing the actual calorific value of the coal than do the values of commercial coal, and average county values based upon such determinations furnish a means of judging the relative accuracy of individual analyses. The ash- and moisture-free B. t. u. value is often called "Pure coal".

If a basic value of greater accuracy in comparison is desired the county average unit coal value⁵ may be used. This B. t. u. value is the calorific value

⁵ Parr, S. W., Chemical study of Illinois Coal: Illinois Coal Mining Investigations Bull. 3, p. 52. 1916.

of the coal as mined, corrected for moisture, mineral matter, and sulphur. It is regarded as the most accurate expression that has been devised for the heat value of the pure coal substances. (Item 4 in tables of analyses.)

B. T. U. VALUE OF CARBON, HYDROGEN, AND SULPHUR

The B. t. u. value of the combustible elements given as the last item in each analysis included in Table 16 is calculated from the known calorific value of carbon, hydrogen, and sulphur. It is not like other heat values determined by actual experimentation but is mathematically derived. The values are of interest only as providing a basis for comparing the theoretical calorific value of the combustible elements in coal. These theoretical values are lower than are the values which are obtained by calculating the derived calorific value of moist commercial coal to a noncombustible-free basis.

Figure 44 shows the average B. t. u. value of Illinois coal on an "as received" basis for the mining districts of the State. When heat values are mapped on a "pure coal" basis sharper distinctions can be made in the heat values of the coal produced in the various districts. Mapping is still more refined when done on the basis of "unit coal" values, so that it is commonly possible to differentiate the coal mined in contiguous counties on the basis of the "pure coal," and even more satisfactorily on the basis of "unit coal" values.

Although proximate and ultimate analyses are useful as a basis for estimating the value of a coal under ordinary conditions of use, that is as a raw fuel, it is believed that in the not far distant future manufactured fuels will be made from coal which in their burning will utilize much more of the fuel value of coal than is possible in burning raw coal.

TABLE 13.—*County averages of proximate analyses of Illinois coals*

1. Moist Commercial Coal as loaded, weighed and billed at mine.
2. Moisture-free or Dry Coal.
3. Moisture- and Ash-free Coal.
4. Moisture- Ash- and Sulphur-free Coal or Unit Coal expressed in B. t. u.'s.

County	Coal Number	Condition	Moisture	Ash	Volatile Matter	Fixed Carbon	Sulphur	B. t. u.
Bond	6	1	11.92	10.73	35.15	42.20	3.39	10,796
		2		12.18	39.91	47.91	3.85	12,257
		3			45.45	54.55	4.38	13,957
		4						14,239
Bureau	2	1	16.11	7.41	38.44	38.04	2.92	10,896
		2		8.83	45.82	45.35	3.48	12,989
		3			50.26	49.74	3.82	14,247
		4						14,469
Christian	1?	1	11.31	8.86	38.89	40.94	2.34	11,602
		2		9.99	43.85	46.16	2.64	13,082
		3			48.71	51.29	2.93	14,534
		4						14,756
Christian	2?	1	12.97	6.92	39.17	40.94	3.13	11,591
		2		7.95	45.01	47.04	3.60	13,318
		3			48.90	51.10	3.91	14,468
		4						14,690
Christian	6	1	12.70	10.20	36.95	40.15	3.91	10,863
		2		11.68	42.33	45.99	4.48	12,443
		3			47.93	52.07	5.07	14,088
		4						14,389
Clinton	6	1	12.37	10.23	35.48	41.92	3.36	10,877
		2		11.67	40.49	47.84	3.84	12,413
		3			45.84	54.16	4.35	14,053
		4						14,329
Franklin	6	1	9.42	8.54	33.91	48.13	1.45	11,797
		2		9.43	37.43	53.14	1.60	13,024
		3			41.23	58.77	1.77	14,380
		4						14,554
Fulton	1	1	11.21	10.21	38.42	40.16	4.96	11,470
		2		11.50	43.27	45.23	5.59	12,918
		3			48.89	51.11	6.32	14,597
		4						14,956
Fulton	5	1	15.09	11.02	35.45	38.44	3.22	10,486
		2		12.98	41.75	45.27	3.79	12,349
		3			47.98	52.02	4.36	14,191
		4						14,493

Interrogated numbers of coal beds are those which are used locally, but which remain to be verified by state-wide studies.

^a Compiled by the Coal Section of the State Geological Survey from analyses of face samples made by the University of Illinois, the United States Geological Survey, or the United States Bureau of Mines. The Schuyler County coal No. 2 average is the only one based on less than three analyses. The county averages represent the average of mine averages, none of which is based on less than two analyses. Most of the analyses used were made since 1910, none before 1905.

TABLE 13.—*Proximate analyses—continued*

County	Coal Number	Condi- tion	Moisture	Ash	Volatile Matter	Fixed Carbon	Sulphur	B. t. u.
Gallatin (north of Eagle Valley) (two mines)	5	1	4.85	11.10	35.58	48.47	3.42	12,327
		2		11.67	37.39	50.94	3.59	12,955
		3			42.33	57.67	4.06	14,667
		4						14,956
Gallatin (Eagle Val- ley only) (three mines)	6	1	5.77	10.88	35.92	47.43	3.84	12,346
		2		11.55	38.12	50.33	4.08	13,102
		3			43.10	56.90	4.61	14,822
		4						15,136
Greene (two mines)	4?	1	14.43	9.42	36.14	40.01	3.91	10,890
		2		11.01	42.23	46.76	4.57	12,727
		3			47.45	52.55	5.14	14,302
		4						14,601
Grundy (three mines)	2	1	17.20	5.22	38.23	39.35	2.27	11,112
		2		6.31	46.17	47.52	2.74	13,420
		3			49.28	50.72	2.92	14,324
		4						14,488
Henry (four mines)	1	1	15.84	9.00	37.08	38.08	4.75	10,658
		2		10.69	44.06	45.25	5.64	12,664
		3			49.33	50.67	6.32	14,180
		4						14,507
Jackson (Murphysboro District only) (five mines)	2	1	9.28	5.72	33.99	51.01	1.29	12,489
		2		6.31	37.47	56.22	1.42	13,766
		3			39.99	60.01	1.52	14,693
		4						14,820
Jackson (one mine)	6	1	9.43	9.77	34.69	46.11	2.06	11,607
		2		10.79	38.30	50.91	2.27	12,816
		3			42.93	57.07	2.54	14,366
		4						14,584
Jefferson (one mine)	6	1	8.5	8.7	34.6	48.2	1.3	11,980
		2		9.5	37.8	52.7	1.4	13,090
		3			41.8	58.2	1.6	14,460
		4						14,630
Knox (two mines)	1?	1	14.28	7.94	36.70	41.08	4.54	11,167
		2		9.26	42.81	47.93	5.30	13,027
		3			47.18	52.82	5.83	14,356
		4						14,653
Knox (one mine)	4	1	14.98	7.73	37.97	39.32	3.87	11,222
		2		9.09	44.66	46.25	4.55	13,199
		3			49.13	50.87	5.00	14,519
		4						14,794
LaSalle (seven mines)	2	1	14.56	8.56	38.28	38.60	3.36	11,022
		2		10.02	44.80	45.18	3.93	12,900
		3			49.79	50.21	4.37	14,337
		4						14,599

Interrogated numbers of coal beds are those which are used locally, but which remain to be verified by state-wide studies.

TABLE 13.—*Proximate analyses—continued*

County	Coal Number	Condi- tion	Moisture	Ash	Volatile Matter	Fixed Carbon	Sulphur	B. t. u.
LaSalle (one mine)	5(6?)	1	14.76	9.65	41.33	34.26	3.38	10,674
		2		11.32	48.49	40.19	3.97	12,522
		3			54.67	45.33	4.48	14,120
		4						14,399
LaSalle (one mine)	7	1	13.56	7.77	40.87	37.80	3.68	11,347
		2		8.99	47.28	43.73	4.26	13,127
		3			51.95	48.05	4.68	14,424
		4						14,684
Livingston ... (two mines)	5?	1	11.59	12.65	35.73	40.03	3.94	11,054
		2		14.31	40.41	45.28	4.46	12,503
		3			47.16	52.84	5.20	14,591
		4						14,959
Logan (two mines)	5	1	13.50	10.64	36.84	39.02	3.16	10,740
		2		12.30	42.59	45.11	3.65	12,416
		3			48.56	51.44	4.16	14,157
		4						14,442
Macon (two mines)	5	1	13.89	10.21	36.18	39.72	3.42	10,701
		2		11.86	42.02	46.12	3.97	12,427
		3			47.67	52.33	4.50	14,099
		4						14,385
Macoupin (eleven mines)	6	1	13.32	9.80	37.42	39.46	4.00	10,736
		2		11.31	43.17	45.52	4.61	12,386
		3			48.68	51.32	5.20	13,965
		4						14,259
Madison (seven mines)	6	1	13.04	10.03	37.96	38.97	4.02	10,813
		2		11.54	43.65	44.81	4.62	12,434
		3			49.35	50.65	5.22	14,056
		4						14,357
Marion (three mines)	6	1	10.31	11.06	36.55	42.08	3.80	11,227
		2		12.34	40.75	46.91	4.24	12,517
		3			46.49	53.51	4.84	14,279
		4						14,590
Marshall (two mines)	2	1	15.10	7.18	39.08	38.64	2.79	11,312
		2		8.46	46.03	45.51	3.29	13,324
		3			50.29	49.71	3.60	14,555
		4						14,777
*Marshall ... (six mines)	7	1	15.29	14.12	35.27	35.32	3.51	10,053
		2		16.67	41.63	41.70	4.13	11,868
		3			49.96	50.04	4.96	14,242
		4						14,627

Interrogated numbers of coal beds are those which are used locally, but which remain to be verified by state-wide studies.

* Based on analyses by University of Illinois and/or U. S. Bureau of Mines of face samples collected under supervision of State Geological Survey in co-operation with Zeigler Coal and Coke Company.

TABLE 13.—*Proximate analyses—continued*

County	Coal Number	Condi- tion	Moisture	Ash	Volatile Matter	Fixed Carbon	Sulphur	B. t. u.
McDonough .. (two mines)	2	1	16.63	8.30	34.19	40.88	2.94	10,804
		2		9.96	41.01	49.03	3.53	12,959
		3			45.55	54.45	3.93	14,392
		4						14,642
McLean	2	1	11.27	8.80	42.21	37.72	3.03	11,566
		2		9.92	47.57	42.51	3.41	13,035
		3			52.81	47.19	3.79	14,470
		4						14,717
McLean	5	1	13.32	12.47	38.00	36.21	3.73	10,580
		2		14.38	43.84	41.78	4.30	12,206
		3			51.20	48.80	5.02	14,256
		4						14,605
Menard	5	1	16.25	8.77	36.34	38.64	3.37	10,521
		2		10.47	43.39	46.14	4.02	12,562
		3			48.46	51.54	4.48	14,030
		4						14,293
Mercer	1	1	15.64	8.97	38.51	36.88	4.44	10,747
		2		10.63	45.65	43.72	5.26	12,739
		3			51.08	48.92	5.88	14,254
		4						14,570
Montgomery..	6	1	13.26	10.02	36.33	40.39	4.27	10,725
		2		11.55	41.88	46.57	4.92	12,365
		3			47.35	52.65	5.56	13,979
		4						14,288
Moultrie	6?	1	6.73	11.60	39.06	42.61	4.16	11,906
		2		12.44	41.88	45.68	4.46	12,765
		3			47.82	52.18	5.09	14,579
		4						14,911
Peoria	5	1	14.61	11.10	35.05	39.24	3.11	10,661
		2		13.00	41.05	45.95	3.64	12,485
		3			47.18	52.82	4.18	14,351
		4						14,654
Perry (east) ^a (two mines)	6	1	10.32	9.38	33.01	47.29	0.92	11,445
		2		10.46	36.81	52.73	1.03	12,762
		3			41.11	58.89	1.15	14,253
		4						14,421
Perry (west) ^a (ten mines)	6	1	10.09	10.66	36.19	43.06	3.34	11,142
		2		11.86	40.25	47.89	3.71	12,393
		3			45.67	54.33	4.21	14,061
		4						14,336
Randolph	5?	1	10.73	10.35	36.38	42.54	4.31	11,150
		2		11.60	40.75	47.65	4.83	12,490
		3			46.10	53.90	5.46	14,128
		4						14,441

Interrogated numbers of coal beds are those which are used locally, but which remain to be verified by state-wide studies.

^a There is a difference in quality on the east and west of the Duquoin anticline.

TABLE 13.—*Proximate analyses—continued*

County	Coal Number	Condi- tion	Moisture	Ash	Volatile Matter	Fixed Carbon	Sulphur	B. t. u.
Randolph (four mines)	6	1	10.07	11.63	36.72	41.58	3.96	10,988
		2		12.93	40.83	46.24	4.40	12,218
		3			46.89	53.11	5.05	14,032
		4						14,349
Rock Island .. (one mine)	1	1	16.61	8.48	35.66	39.25	4.82	10,615
		2		10.17	42.76	47.07	5.78	12,729
		3			47.60	52.40	6.43	14,170
		4						14,493
Saline (sixteen mines)	5	1	6.68	8.39	34.25	50.68	2.55	12,406
		2		8.99	36.70	54.31	2.73	13,294
		3			40.33	59.67	3.00	14,607
		4						14,818
Sangamon (nine mines)	5	1	14.10	10.52	36.41	38.97	4.00	10,657
		2		12.25	42.39	45.36	4.65	12,406
		3			48.31	51.69	5.30	14,138
		4						14,456
Sangamon (three mines)	6	1	13.91	9.96	36.91	39.22	4.13	10,696
		2		11.57	42.87	45.56	4.80	12,424
		3			48.48	51.52	5.43	14,049
		4						14,357
Schuyler (one mine)	2	1	12.53	7.54	37.84	42.09	4.54	11,731
		2		8.62	43.26	48.12	5.19	13,411
		3			47.34	52.66	5.68	14,676
		4						14,973
Schuyler (one mine)	5	1	15.19	9.88	34.69	40.24	2.65	10,844
		2		11.65	40.90	47.45	3.12	12,786
		3			46.29	53.71	3.53	14,472
		4						14,737
Shelby (one mine)	5	1	11.21	10.74	35.24	42.81	3.58	11,071
		2		12.10	39.69	48.21	4.03	12,469
		3			45.15	54.85	4.58	14,185
		4						14,481
St. Clair (ten mines)	6	1	11.12	11.32	37.95	39.61	3.80	10,972
		2		12.73	42.70	44.57	4.27	12,345
		3			48.93	51.07	4.89	14,146
		4						14,458
Tazewell (two mines)	5	1	15.14	9.47	35.72	39.67	3.20	10,735
		2		11.16	42.09	46.75	3.77	12,650
		3			47.38	52.62	4.25	14,239
		4						14,512
Vermilion ... (five mines)	6?	1	14.42	9.32	35.16	41.10	2.49	10,942
		2		10.89	41.08	48.03	2.91	12,786
		3			46.10	53.90	3.26	14,349
		4						14,590

Interrogated numbers of coal beds are those which are used locally, but which remain to be verified by state-wide studies.

TABLE 13.—*Proximate analyses—concluded*

County	Coal Number	Condi- tion	Moisture	Ash	Volatile Matter	Fixed Carbon	Sulphur	B. t. u.
Vermilion ... (two mines)	7?	1	13.29	9.82	37.59	39.30	2.84	11,151
		2		11.33	43.35	45.32	3.28	12,860
		3			48.89	51.11	3.70	14,503
		4						14,770
Warren (two mines)	1	1	13.15	8.57	39.42	38.86	5.49	11,224
		2		9.87	45.39	44.74	6.32	12,924
		3			50.36	49.64	7.01	14,339
		4						14,683
Washington... (two mines)	6	1	10.12	11.71	38.40	39.77	4.14	10,987
		2		13.03	42.72	44.25	4.60	12,224
		3			49.12	50.88	5.29	14,055
		4						14,382
White (one mine)	6	1	8.54	8.96	35.37	47.13	2.86	11,918
		2		9.80	38.67	51.53	3.13	13,031
		3			42.87	57.13	3.47	14,447
		4						14,681
Will (one mine)	2	1	15.28	5.57	33.86	45.29	1.80	11,287
		2		6.57	39.92	53.51	2.12	13,323
		3			42.75	57.25	2.26	14,260
		4						14,407
Williamson... (one mine)	5?	1	6.96	11.17	34.00	47.87	3.50	11,890
		2		12.00	36.53	51.47	3.76	12,779
		3			41.53	58.47	4.27	14,522
		4						14,818
Williamson... (twenty-eight mines)	6	1	6.69	9.45	36.01	47.85	3.55	12,025
		2		10.12	38.60	51.28	3.81	12,887
		3			42.95	57.05	4.24	14,338
		4						14,598

Interrogated numbers of coal beds are those which are used locally, but which remain to be verified by state-wide studies.

TABLE 14—*Average proximate and ultimate values of coal by trade district and seam^a*
(Commercial mine run as loaded, weighed and billed at mine)

District ^b	Coal No.	Moisture	Ash	Volatile Matter	Fixed Carbon	Sulphur	Commercial Coal	B. t. u. Moisture- and Ash-Free	Unit Coal
NORTHERN ILLINOIS									
1. Wilmington	2	16.24	5.39	36.05	42.32	2.04	11,200	14,292	14,449
2a. Longwall (Third Vein) (Bureau, LaSalle, and Marshall counties)	2	15.26	7.71	38.60	38.43	3.03	11,076	14,379	14,616
2b. Longwall ^c (Second Vein) LaSalle County	5 (6?)	14.76	9.65	41.33	34.26	3.38	10,674	14,120	14,399
2c. Longwall (Streator and Sparland coal, LaSalle and Marshall counties) (First Vein coal)	7	14.43	10.98	38.04	36.55	3.59	10,695	14,337	14,657
CENTRAL ILLINOIS									
3a. McLean County ^d (Third Vein)	2	11.27	8.80	42.21	37.72	3.03	11,566	14,470	14,717
3b. McLean County ^d (Second Vein)	5	13.32	12.47	38.00	36.21	3.73	10,580	14,256	14,605
4. Livingston County ^d	5?	11.59	12.65	35.73	40.03	3.94	11,054	14,591	14,959
5a. Danville (Grape Creek coal) Vermilion County.	6?	14.42	9.32	35.16	41.10	2.49	10,942	14,349	14,590
5b. Danville (Danville coal) (Vermilion County)	7?	13.29	9.82	37.59	39.30	2.84	11,151	14,503	14,770
6. Springfield (Logan, Ma- con, Menard, Sangamon and Shelby counties)	5	13.79	10.16	36.23	39.82	3.50	10,738	14,121	14,411
7. Moultrie County ^d	6?	6.73	11.60	39.06	42.61	4.16	11,906	14,579	14,911

TABLE 14—Average proximate and ultimate values of coal by trade district and seams—continued
(Commercial mine run as loaded, weighed and billed at mine)

District ^b	Coal No.	Mois- ture	Ash	Vola- tile Matter	Fixed Carbon	Sul- phur	Commercial Coal	B. t. u. Mois- ture- and Ash-Free	Unit Coal
WESTERN ILLINOIS									
8. Fulton, ^c Henry, ^c Mercer, ^d Rock Island, ^d Warren, ^d and Knox ^d counties.....	1	14.46	8.85	37.63	39.06	4.83	10,978	14,316	14,643
9. Fulton-Peoria (Fulton, Peoria, and Tazewell counties)	5	14.95	10.53	35.41	39.11	3.17	10,626	14,259	14,552
10. Soperville (Knox County) ^c	4	14.98	7.73	37.97	39.32	3.87	11,222	14,519	14,794
11a. Schuyler and McDonough counties ^c	2	14.58	7.93	35.99	41.50	3.72	11,263	14,535	14,808
11b. Schuyler County ^c	5	15.19	9.88	34.69	40.24	2.65	11,263	14,535	14,808
SOUTHERN ILLINOIS									
12a. Christian County ^d	1	11.31	8.86	38.89	40.94	2.34	11,602	14,534	14,756
12b. Christian County ^d	2	12.97	6.92	39.17	40.94	3.13	11,591	14,468	14,690
13. Greene County ^c	4?	14.43	9.42	36.14	40.01	3.91	10,890	14,302	14,601
14. Standard (Bond, Christian, Clinton, Macoupin, Madi- son, and Sangamon coun- ties)	6	12.93	10.13	36.61	40.33	3.88	10,787	14,021	14,317
15. Centralia (Marion County and northeastern Wash- ington County)	6	10.17	11.02	36.80	42.01	3.46	11,138	14,133	14,416
16a. Belleville (St. Clair and Randolph counties)	6	10.59	11.47	37.35	40.59	3.87	10,980	14,089	14,403

TABLE 14—Average proximate and ultimate values of coal by trade district and seam^a—concluded
(Commercial mine run as loaded, weighed and billed at mine)

District ^b	Coal No.	Mois- ture	Ash	Vola- tile Matter	Fixed Carbon	Sul- phur	Commercial Coal	B. t. u. Mois- ture- and Ash-Free	Unit Coal
16b. Perry and Jackson (west of Duquoin anticline)...	6	9.76	10.21	35.44	44.59	2.70	11,375	14,214	14,461
16c. Randolph County ^c	5	10.73	10.35	36.38	42.54	4.51	11,150	14,128	14,441
17. Murphysboro ^d (Big Mud- dy) Jackson County	2	9.28	5.72	33.99	51.01	1.29	12,489	14,693	14,820
18. Franklin - Williamson (Franklin, Williamson, Jefferson, eastern Perry, White and Gallatin coun- ties; east of Duquoin anticline)	6	8.41	9.30	34.39	47.90	2.03	11,902	14,463	14,673
19. Southeastern Illinois (Sa- line, Gallatin and Wil- liamson counties)	5	6.16	10.22	34.60	49.02	3.15	12,208	14,599	14,864
20. Eagle Valley ^c (Gallatin County)	5	4.14	8.86	34.20	52.80	3.42	12,986	14,929	15,186

Interrogated numbers of coal beds are those which are used locally, but which remain to be verified by state-wide studies.

^a Based upon analyses made by the University of Illinois, the United States Geological Survey, or the United States Bureau of Mines.

^b The counties listed are those represented in the average analyses given.

^c No shipping mines.

^d No production, mines abandoned.

TABLE 15.—*County averages of ultimate analyses of Illinois coal^a*
(Standard form)

1. Moist Commercial Coal as loaded, weighed and billed at mine.
2. Moisture-free, or Dry Coal.
3. Moisture- and Ash-free Coal.
4. Moisture- Ash- and Sulphur-free Coal or Unit Coal expressed in
B. t. u.'s.

County	Coal Seam	Condi- tion	Mois- ture	Ash	Carbon	Hydro- gen	Sul- phur	Nitro- gen	Oxygen	B. t. u.
Bond	6	1	11.92	10.73	60.94	4.13	3.39	1.08	7.81	10,796
		2		12.18	69.19	4.68	3.85	1.23	8.87	12,257
		3			78.79	5.33	4.38	1.40	10.10	13,957
		4			82.40	5.57		1.47	10.56	14,239
Bureau	2	1	16.11	7.41	60.05	4.14	2.92	1.06	8.31	10,896
		2		8.83	71.58	4.94	3.48	1.26	9.91	12,989
		3			78.51	5.42	3.82	1.38	10.87	14,247
		4								14,469
Christian	6	1	12.70	10.20	59.75	4.32	3.91	1.12	8.00	10,863
		2		11.68	68.44	4.95	4.48	1.28	9.17	12,443
		3			77.49	5.61	5.07	1.45	10.38	14,088
		4			81.63	5.91		1.53	10.93	14,389
Clinton	6	1	12.37	10.23	60.34	4.14	3.36	1.10	8.46	10,877
		2		11.67	68.86	4.73	3.84	1.25	9.65	12,413
		3			77.96	5.36	4.35	1.41	10.92	14,053
		4			81.51	5.60		1.47	11.42	14,329
Franklin	6	1	9.42	8.54	66.58	4.32	1.45	1.52	8.17	11,797
		2		9.43	73.50	4.77	1.60	1.68	9.02	13,024
		3			81.15	5.27	1.77	1.85	9.96	14,380
		4			82.61	5.37		1.88	10.14	14,554
Fulton	5	1	15.09	11.02	58.56	3.96	3.22	1.09	7.06	10,486
		2		12.98	68.97	4.66	3.79	1.28	8.32	12,349
		3			79.26	5.35	4.36	1.47	9.56	14,191
		4			82.87	5.59		1.54	10.00	14,493
Greene	4?	1	14.43	9.42	60.02	4.11	3.91	1.12	6.99	10,890
		2		11.01	70.14	4.80	4.57	1.31	8.17	12,727
		3			78.82	5.39	5.14	1.47	9.18	14,302
		4								14,601
Jefferson	6	1	8.5	8.7	67.3	4.4	1.3	1.5	8.3	11,980
		2		9.5	73.5	4.9	1.4	1.6	9.1	13,090
		3			81.2	5.4	1.6	1.8	10.0	14,460
		4			82.5	5.5		1.8	10.2	14,630
LaSalle	2	1	14.56	8.56	61.29	4.13	3.36	1.00	7.10	11,022
		2		10.02	71.74	4.86	3.93	1.17	8.28	12,900
		3			79.73	5.40	4.37	1.30	9.20	14,337
		4			83.37	5.65		1.36	9.62	14,599

^a Based upon analyses made by the University of Illinois, the United States Geological Survey, or the United States Bureau of Mines.

Carbon, hydrogen, nitrogen, and oxygen are recalculated so that the average moisture, ash, and sulphur values agree with those in Table 13.

TABLE 15.—*Ultimate analyses, standard form—continued*

County	Coal Seam	Condi- tion	Mois- ture	Ash	Carbon	Hydro- gen	Sul- phur	Nitro- gen	Oxygen	B. t. u.
Logan (one mine)	5	1	13.50	10.64	60.13	4.13	3.16	1.08	7.36	10,740
		2		12.30	69.52	4.78	3.65	1.25	8.50	12,416
		3			79.27	5.45	4.16	1.43	9.69	14,157
		4			82.71	5.69		1.49	10.11	14,442
Macon (one mine)	5	1	13.89	10.21	59.10	4.17	3.42	1.06	8.15	10,701
		2		11.86	68.63	4.84	3.97	1.23	9.47	12,427
		3			77.86	5.49	4.50	1.40	10.75	14,099
		4			81.53	5.75		1.47	11.25	14,385
Macoupin (six mines)	6	1	13.32	9.80	58.91	4.37	4.00	1.07	8.53	10,736
		2		11.31	67.96	5.05	4.61	1.23	9.84	12,386
		3			76.62	5.69	5.20	1.39	11.10	13,965
		4			80.82	6.00		1.47	11.71	14,259
Madison (three mines)	6	1	13.04	10.03	59.76	4.32	4.02	1.04	7.79	10,813
		2		11.54	68.72	4.97	4.62	1.19	8.96	12,434
		3			77.69	5.62	5.22	1.34	10.13	14,056
		4			81.97	5.93		1.42	10.68	14,357
Marion (two mines)	6	1	10.31	11.06	62.18	4.37	3.80	1.17	7.11	11,227
		2		12.33	69.33	4.88	4.24	1.30	7.91	12,517
		3			79.09	5.57	4.84	1.48	9.02	14,279
		4			83.11	5.85		1.56	9.48	14,590
Marshall (two mines)	7	1	15.29	14.12	55.50	3.96	3.51	1.00	6.62	10,053
		2		16.67	65.52	4.68	4.13	1.18	7.82	11,868
		3			78.62	5.62	4.96	1.42	9.38	14,242
		4								14,627
Montgomery (five mines)	6	1	13.26	10.02	59.39	4.15	4.27	1.13	7.78	10,725
		2		11.55	68.47	4.79	4.92	1.30	8.97	12,365
		3			77.41	5.41	5.56	1.47	10.15	13,979
		4			81.97	5.73		1.55	10.75	14,288
Peoria (four mines)	5	1	14.61	11.10	59.08	4.15	3.11	1.12	6.83	10,661
		2		13.00	69.19	4.86	3.64	1.31	8.00	12,485
		3			79.53	5.59	4.18	1.51	9.19	14,351
		4			83.00	5.83		1.58	9.59	14,654
Perry (east) ^a . . (two mines)	6	1	10.32	9.38	64.59	4.26	0.92	1.43	9.10	11,445
		2		10.46	72.02	4.74	1.03	1.59	10.16	12,762
		3			80.43	5.29	1.15	1.78	11.35	14,253
		4			81.37	5.35		1.80	11.48	14,421
Perry (west) ^a . . (two mines)	6	1	10.09	10.66	62.14	4.15	3.34	1.22	8.40	11,142
		2		11.86	69.11	4.62	3.71	1.36	9.43	12,393
		3			78.41	5.24	4.21	1.54	10.60	14,061
		4			81.86	5.47		1.61	11.06	14,336
Saline (six mines)	5	1	6.68	8.39	69.58	4.59	2.55	1.50	6.71	12,406
		2		8.99	74.56	4.92	2.73	1.61	7.19	13,294
		3			81.93	5.40	3.00	1.77	7.90	14,607
		4			84.46	5.57		1.83	8.14	14,818

^a There is a difference in quality on the east and west of the Duquoin anticline.

TABLE 15.—*Ultimate analyses, standard form—concluded*

County	Coal Seam	Condi- tion	Mois- ture	Ash	Carbon	Hydro- gen	Sul- phur	Nitro- gen	Oxygen	B. t. u.
Sangamon (four mines)	5	1	14.10	10.52	59.22	4.14	4.00	1.14	6.88	10,657
		2		12.25	68.94	4.83	4.65	1.33	8.00	12,406
		3			78.56	5.51	5.30	1.51	9.12	14,138
		4			82.95	5.82		1.60	9.63	14,456
Sangamon (one mine)	6	1	13.91	9.96	59.05	4.18	4.13	1.14	7.63	10,696
		2		11.57	68.59	4.85	4.80	1.32	8.87	12,424
		3			77.56	5.49	5.43	1.49	10.03	14,049
		4			82.01	5.81		1.57	10.61	14,357
Shelby (one mine)	5	1	11.21	10.74	61.22	4.45	3.58	1.21	7.59	11,071
		2		12.10	68.95	5.01	4.03	1.36	8.55	12,469
		3			78.44	5.70	4.58	1.55	9.73	14,185
		4			82.21	5.97		1.62	10.20	14,481
St. Clair (two mines)	6	1	11.12	11.32	61.17	4.17	3.80	1.14	7.28	10,972
		2		12.73	68.83	4.69	4.27	1.29	8.19	12,345
		3			78.87	5.38	4.89	1.48	9.38	14,146
		4			82.92	5.66		1.56	9.86	14,458
Tazewell (one mine)	5	1	15.14	9.47	59.88	4.16	3.20	1.14	7.01	10,735
		2		11.16	70.56	4.90	3.74	1.27	8.82	12,650
		3			79.42	5.51	4.25	1.51	9.31	14,239
		4			82.95	5.75		1.58	9.72	14,512
Vermilion (five mines)	6?	1	14.42	9.32	60.93	4.11	2.49	1.24	7.49	10,942
		2		10.89	71.20	4.80	2.91	1.45	8.75	12,786
		3			79.90	5.39	3.26	1.63	9.82	14,349
		4			82.59	5.57		1.69	10.15	14,590
Vermilion (two mines)	7?	1	13.29	9.82	61.18	4.24	2.84	1.15	7.48	11,151
		2		11.33	70.56	4.88	3.28	1.32	8.63	12,860
		3			79.58	5.50	3.70	1.49	9.73	14,503
		4			82.64	5.71		1.55	10.10	14,770
Washington (one mine)	6	1	10.12	11.71	60.36	4.40	4.14	1.12	8.15	10,987
		2		13.03	67.15	4.90	4.60	1.25	9.07	12,224
		3			77.21	5.63	5.29	1.44	10.43	14,055
		4			81.52	5.95		1.52	11.01	14,382
White (one mine)	6	1	8.54	8.96	66.59	4.52	2.86	1.39	7.14	11,918
		2		9.80	72.81	4.94	3.13	1.52	7.80	13,031
		3			80.72	5.48	3.47	1.69	8.64	14,447
		4			83.62	5.68		1.75	8.95	14,682
Will (one mine)	2	1	15.28	5.57	62.42	4.81	1.80	1.09	9.03	11,287
		2		6.57	73.68	5.63	2.12	1.29	10.71	13,323
		3			78.86	6.03	2.26	1.38	11.47	14,260
		4								14,407
Williamson (thirteen mines)	6	1	7.94	9.25	67.11	4.48	2.19	1.42	7.61	11,932
		2		10.05	72.90	4.87	2.38	1.54	8.26	12,961
		3			81.05	5.41	2.65	1.71	9.18	14,409
		4			83.25	5.56		1.76	9.43	14,620

Interrogated numbers of coal beds are those which are used locally, but which remain to be verified by state-wide studies.

TABLE 16.—*County averages of ultimate analyses of Illinois Coal^a*
(Amplified form)

1. Moist Commercial Coal as loaded, weighed and billed at mine.
2. Moisture-free, or Dry Coal.
3. Moisture- and Ash-free Coal.
4. Moisture- Ash- and Sulphur-free Coal or Unit Coal expressed in B. t. u.'s.
5. Combustible elements. (Calculated B. t. u.)^b

County	Coal Seam	Condition	Noncombustible				Combustible			B. t. u.
			Moisture	Ash	Nitrogen	Water of Composition	Carbon	Hydrogen	Sulphur	
Bond (one mine)	6	1	11.92	10.73	1.08	8.79	60.94	3.15	3.39	10,796
		2		12.18	1.23	9.97	69.19	3.58	3.85	12,257
		3			1.40	11.35	78.79	4.08	4.38	13,957
		4			1.47	11.87	82.39	4.27		14,239
		5					90.30	4.68	5.02	16,291
Bureau (one mine)	2	1	16.11	7.41	1.06	9.35	60.05	3.10	2.92	10,896
		2		8.83	1.26	11.15	71.58	3.70	3.48	12,989
		3			1.38	12.23	78.51	4.06	3.82	14,247
		4			1.43	12.72	81.63	4.22		14,469
		5					90.88	4.70	4.42	16,357
Christian (three mines)	6	1	12.70	10.20	1.12	9.00	59.75	3.32	3.91	10,863
		2		11.68	1.28	10.32	68.44	3.80	4.48	12,443
		3			1.45	11.68	77.49	4.31	5.07	14,088
		4			1.53	12.30	81.63	4.54		14,389
		5					89.20	4.96	5.84	16,345
Clinton (two mines)	6	1	12.37	10.23	1.10	9.54	60.34	3.06	3.36	10,877
		2		11.67	1.25	10.89	68.86	3.49	3.84	12,413
		3			1.41	12.33	77.96	3.93	4.35	14,053
		4			1.47	12.89	81.51	4.13		14,329
		5					90.38	4.58	5.04	16,241
Franklin (eleven mines)	6	1	9.42	8.54	1.52	9.19	66.58	3.30	1.45	11,797
		2		9.43	1.68	10.15	73.50	3.64	1.60	13,024
		3			1.85	11.21	81.15	4.02	1.77	14,380
		4			1.88	11.41	82.61	4.10		14,554
		5					93.34	4.62	2.04	16,546
Fulton (three mines)	5	1	15.09	11.02	1.09	7.94	58.56	3.08	3.22	10,486
		2		12.98	1.28	9.36	68.97	3.62	3.79	12,349
		3			1.47	10.75	79.26	4.16	4.36	14,191
		4			1.54	11.25	82.87	4.34		14,493
		5					90.29	4.74	4.97	16,324
Greene (one mine)	4?	1	14.43	9.42	1.12	7.86	60.02	3.24	3.91	10,890
		2		11.01	1.31	9.18	70.14	3.79	4.57	12,727
		3			1.47	10.31	78.82	4.26	5.14	14,302
		4			1.55	10.87	83.09	4.49		14,601
		5					89.34	4.83	5.83	16,285

^a Based upon analyses made by the University of Illinois, the United States Geological Survey or the United States Bureau of Mines.

^b DuLong's formula (B. t. u.=14544C+62100H+5000S).

TABLE 16.—*Ultimate analyses, amplified form—continued*

County	Coal Seam	Condition	Noncombustible				Combustible			B. t. u.
			Mois- ture	Ash	Nitro- gen	Water of Compo- sition	Carbon	Hydro- gen	Sul- phur	
Jefferson (one mine)	6	1	8.5	8.7	1.5	9.34	67.30	3.36	1.3	11,980
		2		9.5	1.6	10.23	73.50	3.77	1.40	13,090
		3			1.8	11.25	81.20	4.15	1.60	14,460
		4			1.8	11.48	82.50	4.22		14,630
		5					93.39	4.77	1.84	16,640
LaSalle (one mine)	2	1	14.56	8.56	1.00	7.99	61.29	3.24	3.36	11,022
		2		10.02	1.17	9.35	71.74	3.79	3.93	12,900
		3			1.30	10.39	79.73	4.21	4.37	14,337
		4			1.36	10.87	83.37	4.40		14,599
		5					90.28	4.77	4.95	16,340
Logan (one mine)	5	1	13.50	10.64	1.08	8.28	60.13	3.21	3.16	10,740
		2		12.30	1.25	9.56	69.52	3.72	3.65	12,416
		3			1.43	10.90	79.27	4.24	4.16	14,157
		4			1.49	11.37	82.71	4.43		14,442
		5					90.42	4.84	4.74	16,543
Macon (one mine)	5	1	13.89	10.21	1.06	9.17	59.10	3.15	3.42	10,701
		2		11.86	1.23	10.64	68.63	3.67	3.97	12,427
		3			1.40	12.08	77.86	4.16	4.50	14,099
		4			1.47	12.65	81.53	4.35		14,385
		5					89.99	4.81	5.20	16,334
Macoupin (six mines)	6	1	13.32	9.80	1.07	9.60	58.91	3.30	4.00	10,736
		2		11.31	1.23	11.08	67.96	3.81	4.61	12,386
		3			1.39	12.49	76.62	4.30	5.20	13,965
		4			1.47	13.17	80.82	4.54		14,259
		5					88.97	4.99	6.04	16,341
Madison (three mines)	6	1	13.04	10.03	1.04	8.76	59.76	3.35	4.02	10,813
		2		11.54	1.19	10.08	68.72	3.85	4.62	12,434
		3			1.35	11.39	77.69	4.35	5.22	14,056
		4			1.42	12.02	81.97	4.59		14,357
		5					89.03	4.99	5.98	16,346
Marion (two mines)	6	1	10.31	11.06	1.17	8.00	62.18	3.48	3.80	11,227
		2		12.33	1.30	8.92	69.33	3.88	4.24	12,517
		3			1.48	10.17	79.09	4.42	4.84	14,279
		4			1.56	10.68	83.12	4.64		14,590
		5					89.52	5.00	5.48	16,399
Marshall (two mines)	7	1	15.29	14.12	1.00	7.45	55.50	3.13	3.51	10,053
		2		16.67	1.18	8.80	65.52	3.70	4.13	11,868
		3			1.42	10.56	78.62	4.44	4.96	14,242
		4			1.50	11.11	82.72	4.67		14,627
		5					89.32	5.04	5.64	16,403

TABLE 16.—*Ultimate analyses, amplified form—continued*

County	Coal Seam	Condition	Noncombustible				Combustible			B. t. u
			Mois- ture	Ash	Nitro- gen	Water of Compo- sition	Carbon	Hydro- gen	Sul- phur	
Montgomery (five mines)	6	1	13.26	10.02	1.13	8.75	59.39	3.18	4.27	10,725
		2		11.55	1.30	10.09	68.47	3.67	4.92	12,365
		3			1.47	11.41	77.41	4.15	5.56	13,979
		4			1.55	12.08	81.97	4.40		14,288
		5					88.86	4.76	6.38	16,199
Peoria (two mines)	5	1	14.61	11.10	1.12	7.68	59.08	3.30	3.11	10,661
		2		13.00	1.31	8.99	69.19	3.87	3.64	12,485
		3			1.51	10.33	79.53	4.45	4.18	14,351
		4			1.58	10.78	83.00	4.64		14,654
		5					90.21	5.05	4.74	16,493
Perry (east) ^c two mines)	6	1	10.32	9.38	1.43	10.24	64.59	3.12	0.92	11,445
		2		10.46	1.59	11.42	72.02	3.48	1.03	12,762
		3			1.78	12.75	80.43	3.89	1.15	14,253
		4			1.80	12.90	81.37	3.93		14,421
		5					94.10	4.55	1.35	16,579
Perry (west) ^c . . . (two mines)	6	1	10.09	10.66	1.22	9.45	62.14	3.10	3.34	11,142
		2		11.86	1.36	10.51	69.11	3.45	3.71	12,393
		3			1.54	11.93	78.41	3.91	4.21	14,061
		4			1.61	12.45	81.86	4.08		14,336
		5					90.62	4.52	4.86	16,230
Saline (three mines)	5	1	6.68	8.39	1.50	7.55	69.58	3.75	2.55	12,406
		2			1.61	8.08	74.56	4.02	2.73	13,294
		3			1.77	8.89	81.93	4.41	3.00	14,607
		4			1.83	9.16	84.46	4.55		14,818
		5					91.70	4.94	3.06	16,558
Sangamon (four mines)	5	1	14.10	10.52	1.14	7.74	59.22	3.28	4.00	10,657
		2		12.25	1.33	9.01	68.94	3.82	4.65	12,406
		3			1.51	10.27	78.56	4.36	5.30	14,138
		4			1.60	10.86	82.95	4.59		14,456
		5					89.05	4.94	6.01	16,071
Sangamon (one mine)	6	1	13.91	9.96	1.14	8.58	59.05	3.23	4.13	10,696
		2		11.57	1.32	9.97	68.59	3.75	4.80	12,424
		3			1.49	11.25	77.56	4.27	5.43	14,049
		4			1.57	11.94	82.01	4.48		14,357
		5					88.89	4.89	6.22	16,276
Shelby (one mine)	5	1	11.21	10.74	1.21	8.54	61.22	3.50	3.58	11,071
		2		12.10	1.36	9.62	68.95	3.94	4.03	12,469
		3			1.55	10.95	78.44	4.48	4.58	14,185
		4			1.62	11.48	82.21	4.69		14,481
		5					89.65	5.12	5.23	16,480

^c There is a difference in quality on the east and west of the Duquoin anticline.

TABLE 16.—*Ultimate analyses, amplified form—concluded*

County	Coal Seam	Condition	Noncombustible				Combustible			B. t. u.
			Mois- ture	Ash	Nitro- gen	Water of Compo- sition	Carbon	Hydro- gen	Sul- phur	
St. Clair (two mines)	6	1	11.12	11.32	1.14	8.19	61.17	3.26	3.80	10,972
		2		12.73	1.29	9.21	68.83	3.67	4.27	12,345
		3			1.48	10.56	78.87	4.20	4.89	14,146
		4			1.56	11.10	82.92	4.42		14,458
		5					89.66	4.77	5.57	16,281
Tazewell (one mine)	5	1	15.14	9.47	1.14	7.89	59.88	3.28	3.20	10,735
		2		11.16	1.27	9.30	70.56	3.87	3.74	12,650
		3			1.51	10.47	79.42	4.35	4.25	14,239
		4			1.58	10.94	82.95	4.53		14,512
		5					90.23	4.94	4.83	16,432
Vermilion (four mines)	6?	1	14.42	9.32	1.24	8.43	60.93	3.17	2.49	10,942
		2		10.89	1.45	9.85	71.20	3.70	2.91	12,786
		3			1.63	11.06	79.90	4.15	3.26	14,349
		4			1.69	11.43	82.59	4.29		14,590
		5					91.51	4.75	3.74	16,446
Vermilion (one mine)	7?	1	13.29	9.82	1.15	8.41	61.18	3.31	2.84	11,151
		2		11.33	1.32	9.69	70.56	3.82	3.28	12,860
		3			1.49	10.92	79.58	4.31	3.70	14,503
		4			1.55	11.34	82.64	4.47		14,770
		5					90.86	4.92	4.22	16,481
Washington (one mine)	6	1	10.12	11.71	1.11	9.17	60.36	3.39	4.14	10,987
		2		13.03	1.24	10.20	67.16	3.77	4.60	12,224
		3			1.43	11.73	77.22	4.33	5.29	14,055
		4			1.51	12.39	81.53	4.57		14,382
		5					88.92	4.99	6.09	16,336
White (one mine)	6	1	8.54	8.96	1.39	8.03	66.59	3.63	2.86	11,918
		2		9.80	1.52	8.78	72.81	3.96	3.13	13,031
		3			1.69	9.72	80.72	4.40	3.47	14,447
		4			1.75	10.07	83.62	4.56		14,682
		5					91.12	4.97	3.91	16,534
Will (one mine)	2	1	15.28	5.57	1.09	10.16	62.42	3.68	1.80	11,287
		2		6.57	1.29	11.99	73.68	4.35	2.12	13,323
		3			1.38	12.84	78.86	4.66	2.26	14,260
		4			1.41	13.14	80.68	4.77		14,407
		5					91.93	5.43	2.64	16,874
Williamson (nine mines)	6	1	7.94	9.25	1.42	8.56	67.11	3.53	2.19	11,932
		2		10.05	1.54	9.30	72.90	3.83	2.38	12,961
		3			1.71	10.33	81.05	4.26	2.65	14,409
		4			1.76	10.61	83.25	4.38		14,620
		5					92.15	4.84	3.01	16,558

Interrogated numbers of coal beds are those which are used locally, but which remain to be verified by state-wide studies.

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